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The American Heart Journal

VOL. 12 AUGUST, 1936 No. 2

Original Communications

THE USE OF ETIOLOGICAL NOMENCLATURE OF HEART DISEASE IN HOSPITALS IN THE UNITED STATES*

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NEARLY twenty-five years have elapsed since Cabot[1] focused attention on an etiological basis for classifying heart disease. During this time many refinements have been made in diagnosing, and additional factors have been discovered. Much of the credit for the improvement in diagnosing heart disease is due the Committee on Cardiac Clinics of the Association for the Prevention and Relief of Heart Disease in New York City, which in 1923 prepared a nomenclature covering diseases of the heart and blood vessels which it introduced into its various clinics. This nomenclature has been revised from time to time by the Heart Committee of the New York Tuberculosis and Health Association and has been adopted by the American Heart Association which now sponsors its use.[2] It is generally recognized that the prevention of heart disease or postponement of its more serious consequences demands that each etiological factor be attacked separately. The struggle against heart disease is essentially a war of attrition rather than a broad frontal attack.

While gathering information about the prevalence of rheumatic heart disease, rheumatic fever, and chorea among in-patient admissions to hospitals throughout the United States, this office inquired about the use of etiological nomenclature of heart disease in general. Questionnaires were sent to general hospitals and children's hospitals, most of which have capacities of 100 beds or more. While inquiries were directed at most of the hospitals approved for interneships by the American Medical Association, the study was not confined to these institutions. To have done so would have excluded most of the pediatric hos-

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TABLE I

Distribution by States of Hospitals Using Etiological Nomenclature of Heart Disease for Diagnosing In-Patient Admissions During 1934. Order Based on Percentages of Hospitals Indicating Use of Etiological Nomenclature Among Entire Group Sent Questionnaire

STANDING	STATE	NUMBER OF HOSPITALS SENT QUESTIONNAIRE	NUMBER OF HOSPITALS ANSWERING QUESTION ABOUT CLASSIFICATION	NUMBER OF HOSPITALS USING ETIOLOGICAL NOMENCLATURE	PER CENT OF TOTAL NUMBER USING ETIOLOGICAL NOMENCLATURE	PER CENT OF HOSPITALS ANSWERING QUESTION USING ETIOLOGICAL NOMENCLATURE
1	Maine	12	10	7	58.3	70.0
2	Connecticut	19	18	11	57.9	61.1
3	Dist. of Columbia	9	7	5	55.6	71.4
4	Rhode Island	11	8	6	54.6	75.0
5	New Jersey	47	37	23	48.9	62.2
6	New York	123	90	60	48.8	66.7
7	Massachusetts	64	46	30	46.9	65.2
8	Missouri	44	33	20	45.5	60.6
9	Pennsylvania	129	101	57	44.2	56.4
10	Florida	14	11	6	42.9	54.6
11	Louisiana	14	8	6	42.9	75.0
12	Colorado	13	10	5	38.5	50.0
13	Tennessee	26	18	10	38.5	55.6
14	Kansas	21	13	8	38.1	61.5
15	California	64	49	24	37.5	49.0
16	North Dakota	11	6	4	36.4	66.7
17	Nebraska	17	11	6	35.3	54.5
18	Maryland	21	12	7	33.3	58.3
19	New Mexico	9	5	3	33.3	60.0
20	Iowa	31	16	10	32.3	62.5
21	Ohio	61	43	19	31.2	44.2
22	Texas	78	52	24	30.8	46.2
23	Alabama	10	7	3	30.0	42.9
24	Oregon	21	11	6	28.6	54.6
25	Indiana	33	21	9	27.3	42.9
26	Michigan	48	30	13	27.1	43.3
27	Georgia	19	9	5	26.3	55.6
28	Illinois	65	40	17	26.2	42.5
29	Washington	31	20	8	25.8	40.0
30	Minnesota	35	25	9	25.7	36.0
31	Delaware	4	2	1	25.0	50.0
32	South Dakota	16	11	4	25.0	36.4
33	West Virginia	35	16	8	22.9	50.0
34	Wisconsin	49	24	11	22.5	45.8
35	Idaho	9	5	2	22.2	40.0
36	Mississippi	24	12	5	20.8	41.7
37	Kentucky	17	10	3	17.7	30.0
38	South Carolina	18	9	3	16.7	33.3
39	North Carolina	37	21	6	16.2	28.6
40	Virginia	37	23	6	16.2	26.1
41	Vermont	13	9	2	15.4	22.2
42	New Hampshire	15	7	2	13.3	28.6
43	Nevada	9	5	1	11.1	20.0
44	Utah	10	6	1	10.0	16.7
45	Wyoming	10	4	1	10.0	25.0
46	Oklahoma	24	11	2	8.3	18.2
47	Montana	18	8	1	5.6	12.5
48	Arizona	6	2	0	0	0
49	Arkansas	10	1	0	0	0
	Totals	1,461	953	480	32.9	50.4

pitals and many private hospitals with unquestionably high standards but not meeting all of the requirements for recognition. Furthermore, in quite a few states not many hospitals are approved for interneships. Hospitals belonging to the federal government, with the exception of a few Indian hospitals, were excluded as their beneficiaries are limited to certain select groups among whom there are but few children.

Inquiries were sent to 1,461 hospitals, of which 953 answered the question about the use of an etiological nomenclature during the year 1934. Others stated that they had adopted etiological classifications in 1935. These, however, were not included in the present study. Four hundred eighty-one indicated the use of an etiological terminology. This comprised 32.9 per cent of all the hospitals to which questionnaires were sent, or 50.4 per cent of those replying. These hospitals have either adopted systems of nomenclature embodying an etiological classification of heart disease or have incorporated an etiological nomenclature, usually that of the American Heart Association, into existing systems.

In Table I is shown the distribution by states and the District of Columbia of hospitals using etiological nomenclature. On the basis of the percentage indicating the use of etiological terminology in the entire series, hospitals in Maine, Connecticut, the District of Columbia, Rhode Island, New Jersey, New York, Massachusetts, Missouri, Pennsylvania, Florida, Louisiana, and Colorado employed it most frequently and in the order mentioned. Eight of these twelve areas are located along the northeastern seaboard. On the other hand, etiological nomenclature does not appear to be so popular in most of the western states. If this table is studied from the basis of the number of hospitals answering the inquiry the percentages are somewhat higher, and the results, although in some cases slightly different, are essentially similar.

The extent to which etiological nomenclature is used in various sections of the United States is shown in Table II. Etiological systems of classification are employed more frequently by hospitals in the Middle Atlantic and New England states than by hospitals in other parts of the country and are used to a lesser extent in the Rocky Mountain states than in other sections. It is noteworthy that use of etiological nomenclature is more in vogue in that part of the country where the American Heart Association is strongest. Its popularity in New England is largely attributable to the New England Heart Association.

In Table III a study is made of the use of etiological nomenclature among hospitals approved for interneships by the American Medical Association. Of 572 hospitals to which inquiries were sent, replies to this question were received from 474. Two hundred eighty-eight hospitals, 50.3 per cent of the total number from which information was sought, or 60.8 per cent of the hospitals replying to this question, indicated the use of etiological terminology. While it cannot be postulated that hospitals approved for interneships necessarily have higher stand-

TABLE II

DISTRIBUTION BY SECTIONS OF THE UNITED STATES OF HOSPITALS USING ETIOLOGICAL NOMENCLATURE OF HEART DISEASE

SECTION	NUMBER OF HOSPITALS SENT QUESTIONNAIRE	NUMBER OF HOSPITALS REPLYING TO QUESTION REGARDING NOMENCLATURE	NUMBER OF HOSPITALS USING ETIOLOGICAL NOMENCLATURE	PER CENT OF NUMBER SENT QUESTIONNAIRE	PER CENT OF NUMBER REPLYING TO QUESTION ABOUT NOMENCLATURE
New England (Me., N. H., Vt., Mass., R. I., Conn.)	134	98	58	43.3	59.2
Middle Atlantic (N. Y., N. J., Pa.)	299	228	140	46.8	61.4
East North Central (Ohio, Ind., Ill., Mich., Wis.)	256	158	69	27.0	43.7
West North Central (Minn., Iowa, Mo., N. D., S. D., Neb., Kan.)	175	115	61	34.9	53.0
South Atlantic (Del., Md., D. C., Va., W. Va., N. C., S. C., Ga., Fla.)	194	110	47	24.2	42.7
East South Central (Ky., Tenn., Ala., Miss.)	77	47	21	27.3	44.7
West South Central (Ark., La., Okla., Tex.)	126	72	32	25.4	44.4
Mountain (Mont., Idaho, Wyo., Colo., N. M., Ariz., Utah, Nev.)	84	45	14	16.7	31.1
Pacific (Wash., Ore., Calif.)	116	80	38	32.8	47.5
Totals	1,461	953	480	32.9	50.4

ards than other institutions, these hospitals have met certain standards regarding size, organization, and equipment. In them young physicians receive much of their practical clinical training. Many practitioners, especially those settling in the smaller towns and rural areas, continue to diagnose in terms taught them in medical school and hospital days. Hence it is desirable that such hospitals employ the best terminology available.

Although there are notable exceptions a larger proportion of hospitals in the New England and Middle Atlantic states have adopted etiological classifications than in other parts of the country. This becomes espe-

TABLE III

DISTRIBUTION BY STATES OF HOSPITALS APPROVED FOR INTERNESHIPS BY THE AMERICAN MEDICAL ASSOCIATION USING ETIOLOGICAL NOMENCLATURE OF HEART DISEASE

STANDING	STATE	NUMBER HOSPITALS SENT QUESTIONNAIRE	NUMBER HOSPITALS ANSWERING QUESTION ABOUT CLASSIFICATION	NUMBER REPORTING USE OF ETIOLOGICAL NOMENCLATURE	PER CENT OF HOSPITALS SENT QUESTIONNAIRE	PER CENT OF HOSPITALS ANSWERING QUESTION ABOUT CLASSIFICATION
1	Maine	4	4	4	100.0	100.0
2	New Hampshire	1	1	1	100.0	100.0
3	Rhode Island	4	4	4	100.0	100.0
4	West Virginia	4	3	3	75.0	100.0
5	Missouri	22	19	15	68.2	78.9
6	Florida	3	3	2	66.7	66.7
7	New York	78	65	50	64.1	76.9
8	Connecticut	16	15	10	62.5	66.7
9	New Jersey	30	25	18	60.0	72.0
10	Tennessee	10	9	6	60.0	66.7
11	Pennsylvania	69	62	41	59.4	66.1
12	Massachusetts	31	28	17	54.8	60.7
13	Delaware	2	1	1	50.0	100.0
14	District of Columbia	8	7	4	50.0	57.1
15	Georgia	6	4	3	50.0	75.0
16	Kansas	6	6	3	50.0	50.0
17	Louisiana	4	3	2	50.0	66.7
18	North Dakota	2	1	1	50.0	100.0
19	Oregon	4	4	2	50.0	50.0
20	South Carolina	4	3	2	50.0	66.7
21	Texas	18	15	9	50.0	60.0
22	Vermont	2	1	1	50.0	100.0
23	California	25	25	12	48.0	48.0
24	Maryland	13	11	6	46.2	54.5
25	Colorado	9	7	4	44.4	57.1
26	Indiana	12	9	5	41.7	55.6
27	Washington	12	11	5	41.7	45.5
28	Illinois	29	26	12	41.4	46.2
29	Iowa	10	6	4	40.0	66.7
30	Nebraska	10	6	4	40.0	66.7
31	Michigan	21	16	8	38.1	50.0
32	Ohio	27	18	10	37.0	55.6
33	Wisconsin	22	14	8	36.4	57.1
34	Minnesota	13	11	4	30.8	36.4
35	Virginia	7	7	2	28.6	28.6
36	North Carolina	8	7	2	25.0	28.6
37	Utah	5	4	1	20.0	25.0
38	Kentucky	6	6	1	16.7	16.7
39	Oklahoma	6	3	1	16.7	33.3
40	Alabama	3	2	0	0	0
41	Arkansas	4	1	0	0	0
42	Montana	2	1	0	0	0
	Totals	572	474	288	50.3	60.8

cially manifest if only the states with a considerable number of hospitals reporting are taken under consideration. Missouri, a midwestern state, on the other hand, heads the list of states with a large number of hospitals reporting.

In Table IV the use of etiological nomenclature in teaching hospitals is shown. These include hospitals directly under the control of medical

TABLE IV

DISTRIBUTION BY STATES OF TEACHING HOSPITALS USING ETIOLOGICAL NOMENCLATURE OF HEART DISEASE

STANDING	STATE	NUMBER HOSPITALS SENT QUESTIONNAIRE	NUMBER HOSPITALS ANSWERING QUESTION ABOUT CLASSIFICATION	REPORTING USE OF ETIOLOGICAL NOMENCLATURE		
				NUMBER	PER CENT OF HOSPITALS SENT QUESTIONNAIRE	PER CENT OF HOSPITALS ANSWERING QUESTION ABOUT CLASSIFICATION
1	Connecticut	1	1	1	100.0	100.0
2	Indiana	3	3	3	100.0	100.0
3	Kansas	2	2	2	100.0	100.0
4	Louisiana	2	2	2	100.0	100.0
5	Massachusetts	8	8	8	100.0	100.0
6	North Carolina	1	1	1	100.0	100.0
7	Oklahoma	1	1	1	100.0	100.0
8	South Carolina	1	1	1	100.0	100.0
9	New York	24	23	22	91.7	95.7
10	Georgia	4	3	3	75.0	100.0
11	Maryland	4	3	3	75.0	100.0
12	Pennsylvania	17	16	12	70.6	75.0
13	Missouri	10	9	7	70.0	77.8
14	California	6	6	4	66.7	66.7
15	Illinois	12	12	8	66.7	66.7
16	Nebraska	5	3	3	60.0	100.0
17	Wisconsin	5	4	3	60.0	75.0
18	Ohio	11	7	6	54.5	85.7
19	Colorado	2	2	1	50.0	50.0
20	Oregon	4	4	2	50.0	50.0
21	Tennessee	4	4	2	50.0	50.0
22	Texas	4	4	2	50.0	50.0
23	Virginia	2	2	1	50.0	50.0
24	District of Columbia	7	6	3	42.9	50.0
25	Michigan	3	2	1	33.3	50.0
26	Minnesota	4	3	1	25.0	33.3
27	Iowa	1	1	0	0	0
28	Kentucky	1	1	0	0	0
	Totals	149	134	103	69.1	76.9

schools and affiliated institutions whose clinical facilities are available for teaching purposes. Practically all of the teaching hospitals, with the exception of certain children's hospitals, are on the list approved for interneships. Inquiries were sent to 149 teaching hospitals. Replies were received from 134 hospitals, 103 of which indicated the use of

such a classification. This comprised 69.1 per cent of the total, or 76.9 per cent of those replying. All of the nineteen pediatric teaching hospitals replied to the inquiry. Fourteen, or 73.7 per cent, indicated the use of an etiological nomenclature.

In eight of twenty-eight states (including the District of Columbia) every teaching hospital of which inquiries were made stated that it used some form of etiological nomenclature. On the basis of hospitals answering the questionnaire, all of the teaching hospitals in eleven states indicated the use of etiological nomenclature.

From the above it is evident that the most of the more progressive hospitals, especially those engaging in clinical research and used for teaching purposes are employing etiological terms in diagnosing and recording cases of heart disease. It is difficult to see how it is possible to do otherwise and yet interpret clinical findings in the language of modern literature dealing with heart disease.

There appears to be but slight relationship between the type of ownership or control of hospitals and the use of etiological nomenclature of heart disease. State, municipal (including county), incorporated, nonprofit association, church and fraternal hospitals, and those owned by private individuals employ etiological nomenclature to about the same extent, the differences being determined by the section of the country and whether used for teaching or research purposes rather than by any factors inherent in the type of control. This does not apply to smaller hospitals not included in this series. Most of these are mainly surgical hospitals, having relatively few medical cases. The records in such cases often leave much to be desired. Another exception not included in this series are the hospitals of the federal government. With the exception of a few isolated instances, none have adopted etiological classifications. In many government hospitals, notably those of the Veterans Administration,[3] the use of the etiological nomenclature of the American Heart Association is encouraged but is not the basis for official records. The United States Public Health Service employs an etiological nomenclature in its research activities.

The relationship between the use of etiological nomenclature and the size of a city is difficult to determine. In general, its use is more common in the larger cities. Although there are exceptions, etiological nomenclature is more in vogue in the smaller cities which are satellites of the larger medical centers or are the location of state universities with schools of medicine. In others its use is not so frequent as in the larger cities. In the hospitals in smaller towns the use of etiological nomenclature is definitely less common.

SUMMARY AND CONCLUSIONS

1. Four hundred eighty, or 32.9 per cent, of 1,461 general and children's hospitals to which inquiries were made indicated the use of

etiological nomenclature in diagnosing heart disease among in-patient admissions. Of 953 hospitals replying to the question about etiological nomenclature, 50.4 per cent stated that they used it.

2. Among 572 hospitals approved for interneships by the American Medical Association, 288, or 50.3 per cent, of the total number, or 60.8 per cent of the 474 hospitals from which replies were received, indicated the use of etiological nomenclature.

3. Among 149 teaching hospitals, 103, or 69.1 per cent of the total, or 76.9 per cent of the 134 from which answers were received, indicated the use of etiological terminology.

4. It is evident from the above that most of the more progressive institutions have adopted etiological classifications.

5. The extent to which etiological nomenclature of heart disease is used varies considerably in different sections of the country and among the several states. In general, it is more in use in New England and in the Middle Atlantic states than in other parts of the country. It is used to a greater extent in the larger cities and in their vicinity than in the more isolated and smaller communities.

The author is indebted to Dr. Charles C. Wolferth, of the Robinette Foundation of the University of Pennsylvania for a number of helpful suggestions in the preparation of this paper.

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A SURVEY OF HEART DISEASE MORBIDITY IN SAN FRANCISCO*†

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THE report herein presented is unique in that a municipal Department of Public Health recognized the importance of a survey of heart disease morbidity and assembled its facilities for the collection of the main mass of these data. Reports of heart disease morbidity are open to criticism on the grounds that case distribution even in the same geographical locality is heavily influenced by many variable elements. Some of the most important influences we may enumerate as follows: the time of year of the report; the diagnostic ability of the physicians reporting and their adherence to certain standards of classification; the social status of the patients; the locale of the patient when seen, i.e. office, out-patient dispensary, clinic ward, home or private hospital room, and the limitations of the physicians' practices or the case selection of special clinics or hospitals.

In all of the reports previously assembled from various geographical locations, certain of these variables have been taken into account but in no instance, including our own, have all been controlled. In presenting this survey from San Francisco, we are comparing three groups: (1) cases reported in a city-wide survey made by the San Francisco Department of Public Health‡; (2) patients reported in the single month of January, 1932, from the private office, home and hospital practices of eighteen physicians with a known high level of diagnostic ability;

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†The authors wish to acknowledge the assistance of Rosemary T. Kobes, of the San Francisco Heart Committee, Hilda F. Welke, of the Division of Vital Statistics, San Francisco Department of Public Health, and of the staffs of the Out-Patient Clinics of the University of California and Mount Zion Hospitals for their active participation and for the data submitted by them for study; and to express their appreciation to the various other agencies and individuals who participated and supplied reports of cases, particularly, to the San Francisco Heart Committee for its continued interest and stimulation, as well as the active participation of its members.

‡Two surveys were conducted by the San Francisco Department of Public Health, the first for a period of three months beginning March 1, 1932, the second for one year from August 1, 1932. Blank forms were furnished by the Department in each of these surveys, to all physicians and all hospitals in the city. These forms (Table I) were for the purpose of recording certain facts in the case histories of heart disease patients and were to be returned to the Department of Public Health at regular intervals in postage-free envelopes. About 58 physicians reported immediately that they did not see heart cases and consequently could make no returns. During the first survey, 108 physicians and 8 hospitals made reports; in the second survey, 133 physicians and 14 hospitals reported, with the result that about 3,300 cases were made available for study. A preliminary review of these cases, however, disclosed many in which essential information was lacking, and therefore it became necessary to discard them. Some duplications, also, were found, but a total of 3,141 cases remained upon which analyses and compilations were made. In 1933, there were in San Francisco 1,682 registered physicians, and the estimated population for the city for the same year was 681,325.

and (3) from the cardiac out-patient clinics of the University of California and Mount Zion Hospitals, combined, in the same month of January, 1932.

It is believed that certain consistent occurrences may be discovered for the community by agreement in these groups.

TABLE I

DEPARTMENT OF PUBLIC HEALTH — HEART DISEASE MORBIDITY STUDY
City and County of San Francisco

Patient's Initials_____ Case Number_____
(Use this number in your records.)

Age_____ Sex_____ Race_____ Marital Status: S____ M____ W____ D___
Occupation_____ Resident?_____ Nonresident?_____
Patient previously treated for heart disease?_____ If so, when?_____
Heart disease in other members of family?_____
Chief Complaint_____
Rheumatic Fever Syndrome: Acute Rheumatic Fever_____ Chorea_____
"Growing Pains" _____ Other (be specific) _____
Duration of Heart Disease_____ Duration of Etiological Factors_____

Diagnosis:

1. Etiological: Coronary Arteriosclerosis or Degeneration_____ Hypertension_____ Rheumatic Fever_____ Syphilis_____ Congenital_____ Thyroid_____ Functional_____ Subacute Bacterial Endocarditis_____ Other Causes (specify)_____
2. Anatomical: Myocarditis: Infectious_____ Degenerative_____ Pericarditis: Acute_____ With effusion_____ Adhesive_____

Valves:	Aortic	Mitral	Triscuspid	Pulmonary
	Insufficiency____	Insufficiency____	Insufficiency____	Insufficiency____
		Organic____	Organic____	
		Relative____	Relative____	
	Stenosis____	Stenosis____	Stenosis____	Stenosis____

Acute Coronary Occlusion_____ Involvement of great vessels and/or other heart lesions: (specify)_____
3. Physiological: Congestive Failure (With dyspnea, edema, etc.)_____ Angina Pectoris_____ Arrhythmias (specify type)_____

Functional Capacity:

1. Ordinary physical ability_____ 2. Slight limitation_____
3. Marked limitation_____ 4. Complete physical disability_____

*Cardiogram*_____
Date_____
Use check (√) where possible.

_____M.D.
_____Address

Certain local conditions exist in San Francisco which might influence heart disease. The climate is moist but remarkably equable. For the ten-year period, 1920-1930, the average January temperature was 49.2° F.; the average July temperature was 59.9° F. In 1934 the average relative humidity, in per cent, for January was 76, for July, 80, with an average for the year of 76. For comparison it may be of interest to point out that in New York the mean temperature for January, in 1934, was

30.9° F., for July, 74.8° F.; the relative humidity, in per cent, for January was 73, for July, 75, with an annual average of 74. (The readings for humidity are those taken shortly after sunrise. In both cities there is a variation in the readings throughout the day.)

It is commonly believed that typical acute rheumatic fever is much lower in its incidence in San Francisco than in cities of the Middle West or on the Atlantic seaboard, of nearly equal latitude; as, for example, New York (40 degrees 48 minutes), Philadelphia (39 degrees 58 minutes), Saint Louis (38 degrees 38 minutes), as compared with San Francisco (37 degrees 47 minutes). It should be pointed out also, perhaps, that the rarity of the occurrence of the rheumatic syndrome in tropical and subtropical regions is well recognized.

There is a relatively higher percentage of Orientals and a lower percentage of negro population in San Francisco. For the year, 1930, the negro population of San Francisco, was only 0.5 per cent of the total population, while the Chinese constituted 3 per cent. In New York, on the other hand, the negro population was 4.7 per cent of the total population, and all other colored racial groups, including Chinese, were but 0.2 per cent.

There is in the San Francisco population group a somewhat greater percentage of elderly individuals, made up, in part at least, of those who migrate to California after retirement from more active lives elsewhere. Table II shows the age composition of the population.

TABLE II

1930	PER CENT UNDER 15 YR.	PER CENT 15-44 YR.	PER CENT 45 YR. AND OVER
New York	24.4	54.5	21.1
San Francisco	17.0	55.0	28.0
Los Angeles	20.0	60.0	20.0
Pasadena (1934)	Under 45 yr., 61.2%		Over 45 yr., 38.8%

Likewise, no inconsiderable number of individuals in ill health tend to migrate to warmer climates, and we may therefore find a large group of recurrent acute rheumatic fever patients here whose cardiac lesions have developed prior to the establishment of residence in this community. Of interest, also may be the fact that the region is recognized as one in which the incidence of endemic simple goiter and Graves' disease is higher than average throughout the United States.

In a letter to all licensed medical practitioners of San Francisco on March 15, 1932, the Director of Public Health of San Francisco informed them that from that date and for a period of three months, by regulation of the Department of Public Health, heart disease and acute rheumatic fever were made reportable. On August 1, 1932, this regulation was extended for the period of one year. At this time an explanatory letter and a supply of revised forms were sent to all registered physicians and hospitals, enlisting their cooperation in the survey.

The revised form is shown in Table I. The data which we hoped to obtain from these forms are apparent. Certain checks on the diagnoses are permitted by the data given, as, for example, the electrocardiogram findings. Uncomplicated hypertension was entered as distinct from arteriosclerosis, uncomplicated and with hypertension, and the functional capacity was defined rather than offering the American Heart Association's classification of 1, 2a, 2b, and 3, without explanation.

The material from these sources was assembled separately as (1) the preliminary survey of March 15, 1932, to June 15, 1932, and (2) the final survey of August 1, 1932, to August 1, 1933. All the data were used in compiling Table III and column (*c*) of Table IV, but because of certain changes in the forms used beginning August 1, 1932, with certain indicated exceptions, only the second survey of 2,270 cases was used for Tables V, VI, VII and VIII.

An attempt was made, in analyzing the returned forms, to determine whether the agent responsible for the cardiac incapacity was (1) unquestionably the primary cause, (2) a doubtful agent, or (3) definitely a secondary or complicating cause to another primary cardiac disease. Only five of the etiological groups are included in these assembled data as shown in Table III.

TABLE III

	FRANK FACTOR (%)	QUESTIONABLE FACTOR (%)	SECONDARY FACTOR (%)
Congenital	88.8	3.6	7.6
Rheumatic fever	74.6	11.8	13.6
Syphilis	59.7	6.8	33.5
Thyroid	54.3	14.1	31.6
Arteriosclerosis	57.0	6.2	36.8

Arteriosclerosis, syphilis and thyroid disease are shown to be frequently complicating diseases. This is of special interest in thyrotoxicosis in which opinion is generally in agreement that damage from that source is rarely permanent unless superimposed on underlying cardiac damage.

Consideration of Table IV reveals that there is a remarkable agreement in certain etiological groups between the well-controlled surveys in columns (*a*) and (*b*), and the definitely uncontrolled survey of physicians and clinics of unknown diagnostic capacities in column (*c*). This leads one to the impression that the entire survey probably represents a fairly reliable index of the proportionate incidence of the various types of heart disease in San Francisco.

The two clearest discrepancies in these three groups are: in syphilitic heart disease, which, as expected, is found to be less frequent in the higher social group under the care of private physicians than in the clinic group; and in thyroid heart disease which is probably less well

TABLE IV

CLASSIFICATION OF CASES—PER CENT IN EACH GROUP

CLASSIFIED GROUPS	(A) PRIVATE PHYSICIANS		(B) CLINICS		TOTAL (A) AND (B)		(C) DEPT. OF PUB. HEALTH SURVEY		TOTAL (A), (B) AND (C)	
	CASES	PER CENT	CASES	PER CENT	CASES	PER CENT	CASES	PER CENT	CASES	PER CENT
Congenital	11	4.0	8	5.9	19	4.8	179	5.5	198	5.5
Rheumatic fever	58	21.0	28	20.6	86	21.8	702	22.3	788	22.2
Syphilis	5	1.8	22	16.1	27	6.9	226	7.2	233	7.2
Thyroid	20	7.3	4	2.9	24	6.1	77	2.5	101	2.9
Subacute bacterial endocarditis	2	0.7			2	0.5	31	0.99	33	0.9
Arteriosclerosis (uncomplicated)	70	25.4	10	7.3	80	20.3	734	23.4	814	24.9
Arteriosclerosis and hypertension	30	11.0	23	16.9	53	13.4	529	16.9	582	14.7
Hypertension (uncomplicated)	22	8.0	25	18.3	47	11.9	195	6.2	242	6.8
Total—Art.-Hyper. above	122	44.4	58	42.5	180	45.7	1458	46.5	1638	46.4
Cor pulmonale	3	1.1	11	8.1	14	3.2	10	0.4*	24	0.9*
Functional	27	9.8	5	3.7	32	8.1	192	6.1	224	6.3
Total all cases classified†	275				394		3141		3535	

*Includes cases of second city-wide survey only.

†Includes the "miscellaneous" and "unclassified" groups.

recognized by the general practitioner than by the well-trained diagnostician. The incidence of thyrotoxicosis may vary in different social groups, but these data only suggest such a possibility.

An explanation of certain etiological classifications in Table IV is necessary. Under "rheumatic fever" are included all cases with definite histories of rheumatic fever, "growing pains" or chorea, as well as mitral stenosis of doubtful etiology. Under "thyroid" are entered those cases with definite thyrotoxicosis. Only two examples of "myxedema heart" were reported in the series, and these have been placed in the "miscellaneous" and "unclassified" groups. The cases demonstrating frank, presumably uncomplicated, hypertension have been placed in a separate and distinct category from the arteriosclerosis* group, which includes cases in which there was evidence of elevation of blood pressure as well as uncomplicated coronary arteriosclerosis. Included in the arteriosclerosis and hypertension groups were the following percentages of those cases of acute coronary artery occlusion under active care: 17 per cent in the controlled one-month physicians' survey, 3 per cent in the one-month clinic survey, and 5.6 per cent in the second city-wide survey, with approximately 2.5 per cent incidence in each category.

In the various groups, chiefly the "miscellaneous," are included thirty-two cases of pericarditis, grouped as follows: in the one-month controlled private physician survey were seven cases of acute pericarditis and one of adhesive pericarditis; in the one-month controlled clinic survey were one acute pericarditis and two adhesive pericarditis cases; in the second city-wide survey, of 2,270 cases, were thirteen cases of acute pericarditis, two of tuberculous pericarditis and six of adhesive pericarditis. The total incidence was 1.2 per cent. Undoubtedly some of the adhesive pericarditis cases are of unrecognized tuberculous origin.

Scarlet fever was credited as the etiological factor in eleven cases, giving an incidence of 0.41 per cent, in 2,664 cases representing all but the first city-wide survey. Diphtheria was given as a cause in seven cases, an incidence of 0.26 per cent, in this same total number of cases.

Cases of emphysema with evidences of pulmonary arteriosclerosis formed a large portion of the group of cor pulmonale. The high incidence in the one-month clinic survey is due to the special study of an assembled group of patients presenting this type of heart disease, in both the University of California and Mount Zion clinics.

Other causes of cardiac damage, such as trauma, rarer infections, intoxication and neoplasms, are included in the miscellaneous group. The "functional" classification includes effort syndrome and arrhythmias without other evidence of cardiac disease.

In comparing the incidences of the various etiological groups with those obtained in the East, in the Middle West, in the Rocky Mountain

*This term is being replaced by "coronary arteriosclerosis" in classification schemes.

district, in the South, and in the Northwest,[1-15] certain unusual characteristics occur in this survey of San Francisco. The frequency of congenital heart lesions is much higher (5.5 per cent) than in any previous survey. This high percentile incidence has likewise occurred in a survey now under way on the morbidity of heart disease in the San Francisco children of the school and preschool groups, and is probably due to the relative infrequency of rheumatic heart disease in these children. This probably influenced the entire survey figures since one of the most faithful reporting sources of cases was the Municipal School Cardiac Diagnostic Center.

The data on congenital heart disease in Tables V, VI, and VII, show certain interesting characteristics; namely, the higher incidence in females and the predominance in the lower age groups, which fact accounts for the relatively higher percentage in this group as compared with others, of residents, of unmarried social status, and preschool and school occupations. The high percentage with normal physical capacity may mean that in some of these cases the diagnosis of congenital heart disease may have been made erroneously, a circumstance which may be another explanation of the high proportional incidence of this type of heart disease in the survey. This normal function in so many cases may also be explained by the fact that many of these, seriously handicapped because of congenital heart disease, die early in life. This likewise explains, perhaps, the distribution of cases according to duration, with many reported as under six months and again over five years, with a lower frequency in the intervening time intervals.

With the exception of Texas, Oregon, and Virginia, the reported and surveyed incidence of rheumatic heart disease in our study is definitely lower than in other American surveys. Seegal, Seegal and Jost[16, 17] have shown that the incidence of the acute rheumatic syndrome in various hospitals in the United States, diminishes in the lower latitudes, and many others have pointed out its relative infrequency in semitropical and tropical countries. In Table V, column 3, it is found that only 78 per cent of the rheumatic subjects were residents. From other analyses of known cases in school children, it was found that residence was established in San Francisco not infrequently because the affected individuals had acquired their rheumatism prior to coming to California, and, indeed, the family often had migrated here because of the probable beneficial effect of the milder climate of this area.

From Table V it will be seen that valvular involvement is practically universal in this group and that auricular fibrillation occurs in 13 per cent of the cases recorded. It is somewhat surprising that this table fails to show a higher incidence of heart disease in the families of patients with rheumatic involvement than in other etiological classes.

In the assembled data of Dauer[18] on mortality rates of heart disease in various portions of the United States, a situation is found in Cali-

TABLE V

(2,270 CASES REPORTED IN SECOND CITY-WIDE SURVEY)

	STATISTICAL SUMMARY				ANATOMICAL FACTORS			PHYSIOLOGICAL FACTORS		
	PER CENT IN EACH GROUP*									
	SEX									
	M	F	RESIDENT	HEART DISEASE IN FAMILY	ACUTE CORONARY ARTERIAL OCCLUSION	VALVULAR INVOLVEMENT	CONGESTIVE FAILURE	ANGINA PECTORIS	AURICULAR FIBRILLATION	A-V HEART-BLOCK
Congenital	42	58	92	21	--	21	41	--	--	--
Rheumatic fever	49	51	78	22	--	95	28	0.3	13	1
Syphilis	83	17	78	18	2	35	44	7	3	2
Thyroid	21	79	60	14	--	42	19	2	17	1
Subacute bacterial endocarditis	71	29	90	19	--	88	36	--	18	--
Miscellaneous†	69	31	80	21	--	24	52	--	8	4
Arteriosclerosis	66	34	82	23	9	25	40	11	12	3
Hypertension	45	55	73	20	--	24	31	4	11	3
Functional	53	47	93	23	--	33	4	--	--	4
Unclassified	60	40	No analysis made in this group							
Total	59	41	81	22	7	48	35	7	9	1

*Per cent based on total cases in each group, exclusive of those cases in which the particular item of information was not stated.

†Miscellaneous: This group includes those cases in which the etiological factors are named as Communicable Disease, Pulmonary Heart Disease, or Pericarditis.

fornia similar to that in the southern states, as compared to northeastern and east north-central states: in the former, the mortality rates in the age group of 5 to 9 years are generally about one-third of the rates in the age group of 20 to 29 years, whereas in the latter states, the rates are approximately one-half. Thus, California from 1926 to 1929 had a heart disease mortality rate of 8.0 per 100,000 in the age group of 5 to 9, and 25.1 per 100,000 in the age group of 20 to 29, whereas Connecticut had rates of 14.9 and 26.0, respectively, in these groups. For all ages California occupies a middle position, with a mortality rate of 240 as compared to the highest rate of 291 for New Hampshire and 110 in Tennessee, Mississippi, and Wyoming. As previously stated, in a survey now in preparation by some of us on morbidity in San Francisco school children, there is an apparent striking increase in the incidence of rheumatic heart disease above the age of thirteen years, although the commonest age of onset, as reported by Coombs and others, is seven years.

That the disease takes insidious forms in San Francisco, as well as certain southern localities, seems probable, even though the percentage of rheumatic heart disease incidence, as one among all types of heart disease reported in this survey, namely 22.2, is not strikingly lower than that found in surveys in the Northeast and Middle West. In our study the striking difference between clinic and private patient groups noted

in many of the other surveys was not found, namely 20.6 per cent in clinic services and 21.0 per cent in private cases. This may be due to the better living conditions in poorer homes as found in this city, compared with the conditions found in the more congested larger eastern cities. No comparable study of mortality in rheumatic heart disease has been made in San Francisco, but if the relation between the morbidity survey in Virginia, which showed 22 per cent incidence, and the mortality survey by Hedley[19, 20] in adjacent Washington, D. C., which showed 13.3 per cent, obtains in San Francisco, then San Francisco probably has a mortality rate of this same magnitude, since our reported morbidity of 22.2 per cent is almost identical with that for Richmond.

A study of Table VI shows that rheumatic heart disease has no unusual incidence in negro or Oriental races; that, of their youth a high

TABLE VI

STATISTICAL SUMMARY

(2,270 CASES REPORTED IN SECOND CITY-WIDE SURVEY)

GROUPS	PER CENT OF ALL POP. (%)	CONGENITAL (%)	RHEUMATIC FEVER (%)	SYPHILIS (%)	THYROID (%)	SUBACUTE BACT. ENDOCARDITIS (%)	MISCELLANEOUS (%)	ARTERIO-SCLEROSIS (%)	HYPERTENSION (%)	FUNCTIONAL (%)	TOTAL
Total cases analyzed		134	473	179	57	21	45	925	163	184	2,181†
Color—Race											
White	93.8	97.8	97.3	93.7	100.0	95.2	100.0	97.8	93.9	97.9	97.3
Negro	0.6	---	0.6	4.0	---	4.8	---	1.7	4.3	---	1.5
Chinese	2.6	2.2	1.7	2.3	---	---	---	0.4	0.6	1.6	1.0
Japanese	1.0	---	0.4	---	---	---	---	0.1	0.6	0.5	0.2
Other	2.0	---	---	---	---	---	---	---	0.6	---	---
Not stated	---	---	---	1.1	0.8	---	---	0.7	---	---	0.4
Marital Status											
Single	46.0	88.8	50.2	34.2	16.5	42.8	34.1	21.3	16.0	90.7	38.8
Married	43.0	9.0	38.0	38.8	56.3	47.6	54.6	43.2	55.8	7.7	38.0
Widowed	6.9	1.5	8.6	18.0	21.8	---	6.8	29.8	21.2	---	18.2
Divorced	3.1	0.7	3.2	9.0	5.4	9.6	4.5	5.7	7.0	1.6	5.0
Not stated	1.0	---	1.5	0.6	1.6	---	2.2	3.2	4.2	1.1	2.4
Occupation											
Preschool		28.7	2.5	---	---	---	---	---	---	2.8	2.8
School		59.7	27.5	---	---	15.0	11.9	---	0.7	86.1	17.9
Domestic		8.5	31.7	23.9	64.0	20.0	28.6	29.7	49.3	7.0	28.4
Sedentary		---	17.9	25.1	22.0	25.0	16.7	27.6	26.8	1.8	20.7
Requiring physical labor		3.1	20.4	51.0	14.0	40.0	42.8	42.7	23.2	2.3	30.2
Not stated		3.7	5.7	8.9	12.3	4.8	6.7	10.8	15.3	7.1	9.0

*Percentages are based only on those cases reporting the data indicated in the group. The "not stated" percentage is based on the total number of cases reported. This likewise applies to Tables VII and VIII.

†This total does not include 89 cases not classified because of insufficient information. Total cases reported are 2,270.

percentage are unmarried; and that relatively few (20.4 per cent) are in occupations requiring physical labor. The functional capacity of those presenting evidence of rheumatic heart disease is almost equally distributed through the four grades (Table VII). The duration of the disease in the higher age groups of over ten years is somewhat greater than that generally noted. The age distribution (Table VIII) at the time of reporting is about as expected, with 58.3 per cent of the cases between the ages of ten and forty years, with a rapid increase in number up to the age of ten and a slow decrease after the age of forty.

Syphilitic heart disease is about as common as found in other surveys, except in those cities in which the population includes a large negro group. As seen in Table VI, the reported incidence in negroes in San Francisco is fairly high in this survey. Because 83 per cent are males, the unmarried social status and the high percentage of physical laborers are expected (Table VI). The short duration in many cases is somewhat unusual, but these data probably refer to the time interval since the onset of symptoms and do not consider the fact that about 30 per cent of the subjects have probably had the disease itself for a period of more than five years (Table VIII). The high percentage of complete incapacity is not remarkable in a disease so rapidly fatal after the onset of symptoms (Table VII). No reported case was observed in a person

TABLE VII

STATISTICAL SUMMARY

(2,270 CASES REPORTED IN SECOND CITY-WIDE SURVEY)

GROUPS	CONGENITAL (%)	RHEUMATIC FEVER (%)	SYPHILIS (%)	THYROID (%)	SUBACUTE BACT. ENDOCARDITIS (%)	MISCELLANEOUS (%)	ARTERIO-SCLEROSIS (%)	HYPERTENSION (%)	FUNCTIONAL (%)	TOTAL (%)
Functional Capacity										
Ordinary physical ability	61.9	22.3	13.0	16.6	---	15.4	7.2	20.7	91.5	24.4
Slight limitation	18.6	28.4	26.0	38.7	21.4	15.4	24.4	25.2	6.8	23.0
Marked limitation	11.5	28.2	24.4	30.5	42.8	23.0	28.4	35.5	1.1	24.8
Complete phys. disability	8.0	21.1	36.6	14.2	35.8	46.2	40.0	18.6	0.6	27.8
Not stated	15.7	20.7	31.3	14.0	33.3	13.3	22.8	17.2	4.3	20.3
Duration of Disease										
Under 1 mo.	10.6	4.0	3.9	5.3	8.3	16.0	8.8	5.6	5.3	6.8
1 to 6 mo.	14.9	9.3	28.9	10.6	25.0	16.0	20.0	15.9	26.4	17.3
7 to 11 mo.	2.1	1.7	5.4	5.3	---	---	3.5	6.5	5.3	3.4
1 yr. to 2 yr.	8.5	9.6	11.7	13.3	25.0	12.0	18.6	18.7	20.9	14.9
2 yr. to 3 yr.	6.4	8.7	15.6	10.6	8.3	4.0	13.8	12.3	5.3	11.7
3 yr. to 4 yr.	2.1	8.5	9.4	10.6	---	12.0	6.3	13.0	15.8	7.9
4 yr. to 5 yr.	6.4	5.1	4.7	10.6	8.3	12.0	6.0	2.8	5.3	5.6
5 to 9 yr.	19.2	17.0	10.2	21.3	25.1	4.0	14.1	17.7	10.4	15.0
10 yr. and over	29.8	36.1	10.2	13.4	---	24.0	8.9	7.5	5.3	17.4
Indefinite—not stated	64.8	25.2	28.5	33.3	42.8	44.4	38.4	34.3	89.7	40.3

under the age of twenty years, and the peak of frequency, as expected, was in the fifth and sixth decades of life (Table VIII). The report of 3 per cent of auricular fibrillation (Table V), an extremely high figure for known cases of syphilitic heart diseases, leads one to believe that either arteriosclerosis or the rheumatic fever virus may have caused the heart damage in these cases, and a superimposed positive Wassermann reaction led to an erroneous diagnosis. The frequency of occurrence of valvular lesions(aortic and relative mitral insufficiency), angina pectoris, and auriculoventricular heart-block is not remarkable.

TABLE VIII

AGE DISTRIBUTION

(2,270 CASES REPORTED IN SECOND CITY-WIDE SURVEY)

GROUPS	ENTIRE POP. (%)	CONGENITAL (%)	RHEUMATIC FEVER (%)	SYPHILIS (%)	THYROID (%)	SUBACUTE BACT. ENDOCARDITIS (%)	MISCELLANEOUS (%)	ARTERIOSCLEROSIS (%)	HYPERTENSION (%)	FUNCTIONAL (%)	TOTAL (%)
Under 5 yr.	5.1	21.0	1.3	---	---	---	---	---	---	5.5	2.0
5- 9 yr	5.9	30.8	6.4	---	---	---	4.6	---	0.6	19.2	5.0
10-14 yr.	5.7	22.6	11.1	---	---	---	4.6	---	---	38.5	7.1
15-19 yr.	6.7	10.5	10.8	---	---	25.0	4.5	---	---	25.2	5.3
20-24 yr.	9.4	3.0	8.9	0.6	7.3	10.0	6.8	0.1	1.2	0.5	2.7
25-29 yr.	10.2	4.5	9.2	1.7	1.8	10.0	4.5	0.1	2.5	1.6	3.0
30-34 yr.	9.8	0.8	8.3	1.7	7.3	5.0	4.6	0.4	3.0	0.5	2.7
35-44 yr.	18.3	5.2	18.1	14.6	21.8	25.0	18.2	5.0	12.3	3.0	9.9
45-54 yr.	14.1	---	14.2	30.3	23.6	20.0	20.4	20.7	30.0	3.5	18.2
55-64 yr.	8.3	0.8	7.6	36.5	25.5	5.0	25.0	34.6	20.3	1.0	21.8
65-74 yr.	4.0	0.8	3.2	11.8	12.7	---	6.8	28.9	26.4	1.5	16.3
75 yr. or over	1.3	---	0.9	2.8	---	---	---	10.2	3.7	---	4.9
Unknown	1.3	0.7	0.2	0.6	0.4	4.8	2.2	1.8	---	1.0	1.2

The incidence of thyroid heart disease shows an unusual discrepancy between the controlled and uncontrolled divisions of this survey (Table IV). The figure for the total resembles the figures obtained in other surveys. Perhaps the difference can be interpreted as due to a variable degree of diagnostic acuity in the two groups of physicians reporting. The recognized predominance of females over males is shown also in our figures, in which a ratio of nearly 4 to 1 exists (Table V). Many of the patients were nonresidents. Auricular fibrillation, occurring in 17 per cent of these patients, and hypertension, occurring in 26 per cent of the cases, are common complications. Functional capacity was appreciably high. The incidence of valvular involvement to the extent of 42 per cent probably represents relative valvular insufficiencies. The age distribution (Table VIII, through middle life confirms the belief that there is a good possibility that coronary arteriosclerosis to some degree is not infrequently an accompanying factor in severe thyrotoxic disease.

Of the 33 cases of subacute bacterial endocarditis, 19, or 58 per cent, had rheumatic heart disease and 2, or 6 per cent, had congenital heart disease. Eighteen per cent of the patients are reported as having auricular fibrillation (Table V), which is far above the common experience, and 41.7 per cent of the cases were reported as over two years in duration (Table VII). The former finding is difficult to explain unless some of these were cases of recurrent subacute rheumatic heart disease, or cases of streptococcic septicemia of other types than *Streptococcus viridans*. The unusual number of prolonged cases of the disease is probably due to a misunderstanding by the reporting physician who gave the duration of the underlying rheumatic or congenital heart disease rather than that of the active endocarditis. The age distribution is characteristically in late youth and early middle life (Table VIII), and the selection by occupation, social and racial status is not remarkable, except the apparently high incidence in the negro (Table VI). It is unwise to attempt to draw further conclusions from such a small series of cases.

In the "hypertension" group (Table IV) it is remarkable that 6.8 per cent of the total are reported without note of obvious arteriosclerotic involvement of the coronary arteries. Probably these cases should be disregarded as a separate group since there is reported in Table V the occurrence of congestive failure, angina pectoris, and auricular fibrillation, which must represent coronary arteriosclerosis in some of these patients. In other respects, this group parallels the characteristics of the coronary arteriosclerotic group. Other than the hypertension group just discussed (Table IV), 36 per cent of the cases in the arteriosclerotic group have recognized hypertension as a secondary diagnosis. Thus of all cases of arteriosclerotic and hypertensive heart disease in this series, 46 per cent have recognized hypertension underlying the coronary arteriosclerosis. This is lower than the estimate of Fahr[21] that 75 per cent of all patients with coronary arteriosclerosis have or have had hypertension. Our figure of 46 per cent does not include a minor figure, 1.6 per cent of the reported cases that had hypertension as a complication of rheumatic, thyroid, or syphilitic heart disease.

The "coronary arteriosclerosis" group, constituting with the hypertension group 46.4 per cent of all reported cases, has a frequency approximating the incidence reported in other surveys. This is the group which represents the greatest apparent recent increase in heart disease in the United States. As stated by Cohn[22] and others, this is not only due to the saving of lives from infectious diseases in the early decades, but also to the recent downward trend in diagnoses by practicing physicians, of other degenerative diseases, such as arterial disease, including cerebral thrombosis, chronic nephritis, cerebral hemorrhage, and senility. These trends are illustrated for San Francisco by Table IX, showing the aging population, and by Fig. 1, in which

TABLE IX

SAN FRANCISCO: AGE COMPOSITION OF POPULATION

YEAR	UNDER 45 YR.	45 YR. AND OVER
1910	80%	20%
1920	76%	24%
1930	72%	28%

there is a definite increase in heart disease as a cause of death during the last decade, but practically no change, and even a slightly downward curve, in the combined group comprised of all degenerative diseases. This is likewise shown in Table X, where the heart disease death

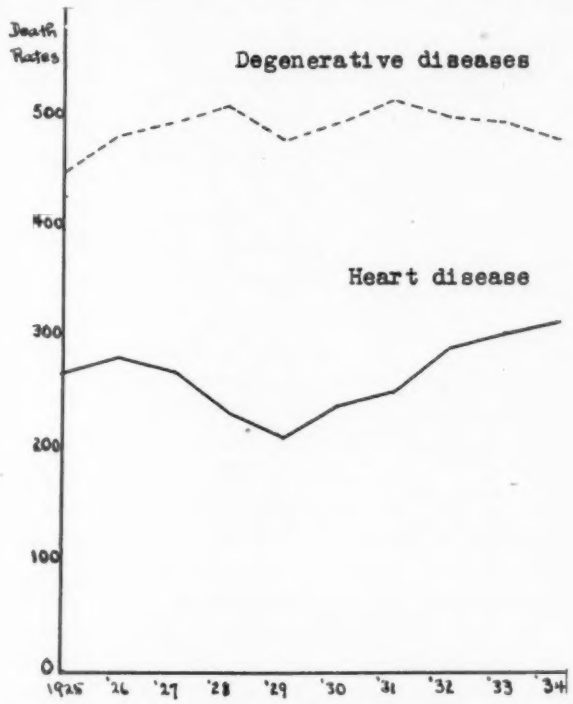

Fig. 1.—San Francisco—mortality from degenerative diseases, and heart disease 1925 to 1934.

rates for the younger ages decrease in 1924 and 1934, whereas the death rates for all ages increase from 259.6 to 316.7 per 100,000 population. Again the influence of an aging population on such crude death rates is shown on comparison of these data with standardized rates (Table XI), in which an adjustment has been made to the standard population age distribution.[23]

A review of Table V shows no unusually high frequency of family history of heart disease in the "coronary arteriosclerosis" or "hypertension" groups. The incidence of 11 per cent of angina pectoris in the former group agrees with most of the other surveys, as does the 12 per

cent of auricular fibrillation and the 3 per cent of heart-block. The rather low incidence of hypertension among Orientals (but high among negroes) is of interest. For closely similar age distributions in the hypertension and the arteriosclerosis groups the degree of incapacity is higher, perhaps, in the latter, than might be expected (Table VII). It is noted, also, that a rather high proportion of these patients are engaged in occupations requiring physical labor (Table VI).

TABLE X

HEART DISEASE IN SAN FRANCISCO, 1924-1934
(SPECIFIC DEATH RATES PER 100,000 IN AGE GROUPS)

AGE GROUPS	MALE				FEMALE			
	1924		1934		1924		1934	
	DEATHS	RATE	DEATHS	RATE	DEATHS	RATE	DEATHS	RATE
Under 35 yr.	46	28.1	32	18.0	43	28.02	31	17.0
35-44 yr.	44	73.2	92	133.9	35	75.1	36	63.3
45-54 yr.	123	294.2	251	465.4	65	208.7	73	171.4
55-64 yr.	215	967.6	329	1069.3	118	662.2	176	678.8
65-74 yr.	271	2987.9	351	2435.1	130	1538.09	270	2027.4
75 yr. or over	186	6092.3	259	6209.6	187	5216.1	274	5766.0
Unknown	1	38.9	---		---		---	
All ages	886	293.06	1314	359.16	578	220.9	860	268.29
Total deaths (Heart disease)	1924—1464 Rate: 259.6				1934—2174 Rate: 316.72			

TABLE XI

CRUDE AND STANDARDIZED DEATH RATES HEART DISEASE IN SAN FRANCISCO
(PER 100,000 POPULATION)

YEAR	CRUDE RATE	STANDARDIZED RATE*
1930	241.88	255.49
1933	305.43	271.26

*Population of England and Wales, 1921 Whipple Vital Statistics, Second Edition, Pages 192, 193; 296, 297.

The greater frequency of females in the uncomplicated hypertension classification, as compared to the higher incidence of males in the "arteriosclerosis" group might be explained by delayed production of symptoms in the more sedentary life of the women (Table V).

The percentage of cases of functional heart disease reported was not high, even in the private practice group, probably because they were excluded as cases of true heart disease. Of those reported 88.4 per cent were in persons under the age of twenty years (Table VIII), a fact perhaps satisfactorily explained on the basis of the circulatory instability of the adolescent period, especially with the large numbers reported from the Department of Public Health School Cardiac Diagnostic Center.

SUMMARY

The etiological classification of 3,535 cases is presented, divided into three brackets, namely, the private hospital and office patients of physicians of known diagnostic ability; the patients from two well-con-

trolled cardiac out-patient clinics; and a city-wide group of patients reported from hospitals and offices by an uncontrolled group of physicians of San Francisco, on an order of the Director of Public Health making heart diseases and the rheumatic fever syndrome reportable for fifteen months. Consideration is given to the reliability of the data.

The data from 2,270 cases reported during the last year of the San Francisco Health Department survey, and in many instances from the whole 3,535 cases, have been assembled for detailed study. This includes for the various etiological groups the incidence of sex, race, age, residence in San Francisco, marital status, occupation, familial heart disease, valvular involvement, congestive heart failure, angina pectoris, auricular fibrillation, auriculoventricular heart-block, functional capacity, and duration of disease.

A comparison is made between findings in the survey reported herein and those of others previously reported by various authors. The most interesting conclusion drawn was that, in San Francisco where the acute rheumatic fever syndrome is uncommon, the general incidence of rheumatic heart disease is approximately the same as that seen in private practice in Boston and New York, although definitely lower than in clinic practice in these eastern centers of population.

NOTE.—The survey of the rheumatic fever syndrome without rheumatic heart disease was unsatisfactory. Only fifty-one cases were reported having acute rheumatic fever, chorea, and/or growing pains without valvular heart disease in the 3,141 reports to the Department of Health.

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RHEUMATIC FEVER IN NORTHERN CALIFORNIA*

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IT IS a common observation among western clinicians that rheumatic fever and heart disease are usually rare and that the rheumatic infection itself is of milder nature than that seen in England or in the eastern United States. Some explanation for this impression should be advanced, but strangely enough is not available in the medical literature.

An analysis of two groups of cases was undertaken to determine the true incidence of the disease.

The first group was examined at the Cardiac Center of the San Francisco Department of Health.[1] The survey of data for this group reveals one outstanding feature—the incidence of congenital heart disease is surprisingly high in San Francisco school and preschool children. Fifty per cent of all organic lesions are those of congenital heart disease. This percentage is a marked contrast to the 12 to 20 per cent usually quoted in statistics from the East. The conclusion to be drawn from these figures is that because there is no valid reason why congenital heart disease should be more frequent in San Francisco than in Boston, the incidence of rheumatic fever must be correspondingly low. This impression has been corroborated by Richter[2] and by Sampson.[3]

Observations of the second group were made between October, 1930, and October, 1935, on 117 patients admitted to the pediatric wards of the San Francisco and University of California Hospitals and to the Children's Heart Clinic of the University of California Out-Patient Department. Complete studies including roentgenograms, fluoroscopy and electrocardiograms were made whenever possible. The same studies were made in the out-patient department group, though for obvious reasons without the completeness possible for hospitalized patients. Follow-up work has been done during the entire five-year period and has materially aided the diagnosis. The follow-up visits are made by the nurses assigned by the Visiting Nurses' Association to cardiac cases.

I have tried to compare my findings with those reported by workers in England and in northeastern United States in an effort to interpret the results of this study. Comparisons with local figures are practically impossible for studies of this type have not been attempted in northern California. This is a statistical summary, but it is hoped that the figures will prove interesting and will call attention to the status of rheumatic infection in California.

*From the Department of Pediatrics Cardiac Clinic, University of California Medical School, San Francisco.

Hospital Incidence (Table I).—It is somewhat surprising to find the hospital incidence of rheumatic infections relatively high in a community where the disease incidence has been observed to be low as is substantiated by the available epidemiological data on school children. The data in Table I reveals the hospital incidence to be double or triple that of similar general and teaching hospitals elsewhere, and even the pediatric wards, which always have a high percentage of infants, have a remarkably high incidence of rheumatic infection. The reasons for this discrepancy will not be apparent without further epidemiological study, but the answer may be among the following: First, the hospital incidence is markedly increased by the numbers of people who emigrate to California for their health. However, this explanation is partially refuted by the low incidence of rheumatic infection in Los Angeles. Second, the low school

TABLE I

HOSPITAL INCIDENCE

HOSPITAL	PERCENTAGE OF TOTAL MEDICAL CASES OF RHEUMATIC FEVER AND CHOREA
Johannesburg, South Africa (European patients[4])	5.80
Glasgow Royal Infirmary, Scotland[4]	4.74
University of California Medical Service	3.79
San Francisco Hospital[4]	3.75
University of California Pediatric and Medical Services	3.44
London Hospital, England[4]	2.75
University of California pediatric wards	2.50
Bellevue, New York[4]	1.50
Peter Bent Brigham, Boston[4]	1.30
Barnes, St. Louis[4]	0.47
Los Angeles County General[4]	0.44
University Hospital, Augusta, Georgia[4]	0.08

incidence and the high hospital incidence may indicate that we are dealing with forms of rheumatic infection, which after an apparently typical onset and course become benign and are not recognizable in routine school examinations. This seems a probable explanation and is one which is applicable to scarlet fever, which by epidemiological fact, is more benign in California. The second explanation appears the more likely in view of the evidence which will be presented.

Family History (Table II).—Family influence is well recognized in the rheumatic infection and has been observed by many in this country and in Europe. Whether this represents a distinct contagious element, inheritance of the susceptibility, transference of an obscure immunological response from mother to child, or the presence of some dietary deficiency in the whole family, as suggested by Rinehart,[5] is a matter for sufficient speculation to intrigue a corps of experimental and epidemiological workers. An understanding of the rôle of these factors will do much to solve the etiological puzzle. A positive family history is present in 32.4 per cent of my 116 cases, which corresponds to the 29 per cent reported

by St. Lawrence[6] in this country and the 40 per cent reported by Poynton and his associates.[7] The agreement with the figure of Findlay[8] (34.7 per cent) is obvious in Table II.

TABLE II

RHEUMATIC INFECTION—POSITIVE FAMILY HISTORY

PLACE OBSERVED	PATIENTS	PATIENTS WITH POSITIVE FAMILY HISTORY	PERCENTAGE POSITIVE FAMILY HISTORY
University of California Pediatric Department	46	15	32.6
University of California Children's Cardiac Clinic	47	16	34.0
San Francisco Hospital Pediatric ward	23	6	28.8
Total	116	37	32.4
Leonard Findlay's Survey[8]	701	243	34.7

Sex Incidence (Tables III and IV).—Sex incidence is hardly to be considered of epidemiological importance, and yet a widely known fact is that the rheumatic infection occurs slightly more frequently in the female than in the male as is shown in Table III.

TABLE III

RHEUMATIC INFECTION—SEX INCIDENCE

PLACE OBSERVED	PATIENTS	MALE	FEMALE
University of California Pediatric Department	46	16	30
University of California Children's Cardiac Clinic	47	24	23
San Francisco Hospital Pediatric Ward	23	16	7
Total	116	56	60
Ratio Male to Female { San Francisco		1:1.07	
Ratio Male to Female { Findlay		1:1.09	

Table IV also reveals that chorea is at least two and a half times more frequent in girls than in boys, an observation which is fairly constant throughout the world.

TABLE IV

CHOREA: SEX INCIDENCE

PATIENTS	MALE	FEMALE	RATIO	
			SAN FRANCISCO	FINDLAY
28	8	20	1:2.5	1:2.8

Age Incidence (Fig. 1).—Numerous recent reports are available in the literature to refute the old idea that rheumatic fever does not occur before the third year. Noteworthy among these reports is that of McIntosh and Wood.[9] Findlay[8] does not report a patient whose onset was under three years of age and my series includes no case recognized before three years of age. Yet there were observed, in my service of 106 con-

secutive rheumatic children under twelve years of age, 14 children in whom the onset was before five years of age. This constitutes 13.2 per cent as compared with 12 per cent reported by Poynton[10] in a similar age group.

Figure 1 is a graphic representation of the age incidence in my group and Findlay's.[8] Although mine is a much smaller group, the similarity in the curves is remarkable, both reaching their peak at seven years of age and falling rapidly to fourteen years of age. In Findlay's series,

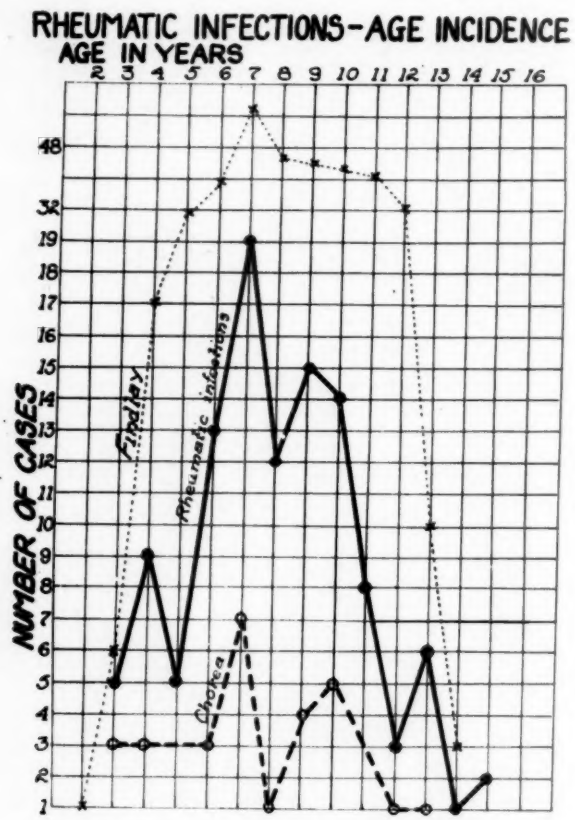

Fig. 1.

52.2 per cent occurred between the seventh and tenth years, Fig. 1 reveals that 54.5 per cent occurred in the same period in the northern California series.

The value of the information is twofold. First, our diagnostic ability is improved by knowledge of time of onset; and second, although rheumatic disease undoubtedly tends to increase in incidence after five years of age, onset of the disease before that time is of considerable prognostic importance. Carditis is most likely to occur in the young and is likely to be severe and even fatal in those under five years of age.

Seasonal Incidence (Fig. 2).—The scope of this paper does not warrant a discussion of the climatology of the rheumatic infection as that factor presents an epidemiological problem in itself. The geographical distribution and the fact that rheumatic fever in the tropics is practically absent is well known. The various factors involved in this distribution are not well understood; but, since it is known that dampness and chilling constitute two major contributory factors, it is not difficult to realize why the peak in the northeastern section of this country occurs during

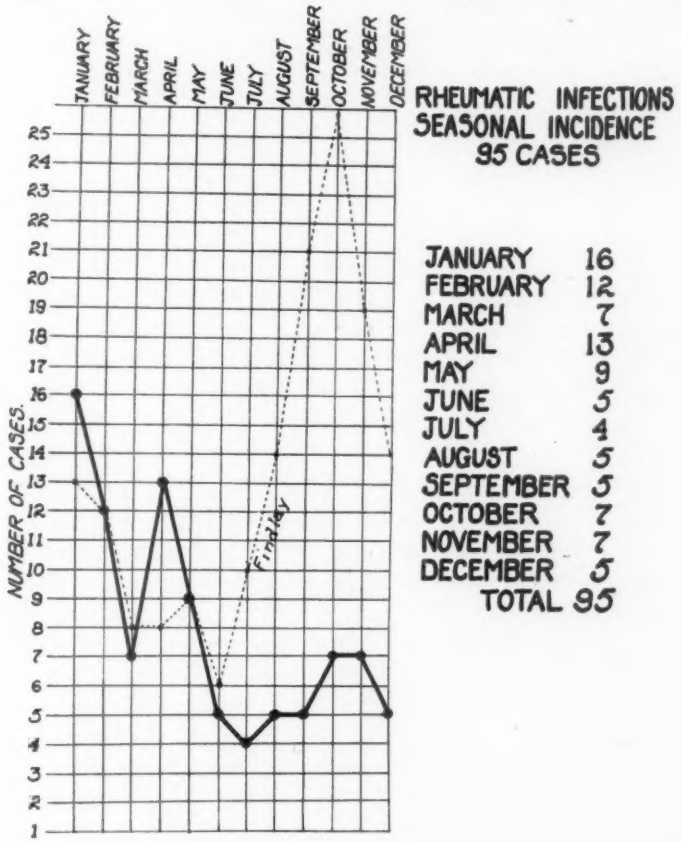

Fig. 2.

the first three to four months of each year, while that in the British Isles occurs in September, October and November. A study of vital statistics[11] seems to substantiate this assumption.

A surprising peak in onset incidence in northern California following a cold and damp December, January, and February is shown in Table V, and I believe this undoubtedly accounts for the difference in incidence between Findlay's seasonal incidence curve and that of northern California. It can only be surmised what benefit these facts are in determining the etiology of rheumatic fever. Whether the cold damp season, with

its increased incidence of respiratory infections, implies an infectious etiology because of changing blood supply of tissue, or whether the general susceptibility of the body is lowered, are questions which continue to intrigue the immunologist and clinician.

TABLE V

AVERAGE MEAN TEMPERATURE BY MONTHS FOR YEARS 1932, 1933, AND 1934 IN SAN FRANCISCO

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
49.3	52.7	57.7	56.8	58.0	59.2	59.7	60.5	62.6	62.1	59.7	50.2

AVERAGE PRECIPITATION IN INCHES BY MONTHS FOR YEARS 1932, 1933, AND 1934 IN SAN FRANCISCO

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
3.31	2.93	1.28	0.34	0.71	0.24			0.09	0.79	1.58	3.66

The Rheumatic Infection—Types of Onset (Tables VI and VII).—The manifestations of rheumatic infection at the onset vary widely: each type is illustrated in the accompanying Table VI. The manifestations at onset can be divided into those of primary and secondary importance, with polyarthritis, chorea, carditis, and subcutaneous nodules comprising the former. Because tonsillitis was present in such a high percentage of my cases, I would like to include this among those manifestations of greatest importance. Scarlet fever, erythema, growing pains, extrasystoles, abdominal pain, and purpura are of secondary importance. Pathologically, each of these manifestations has been adequately explained and in most cases is correctly correlated with the rheumatic infection. Coombs,[12] and later Coburn,[13] covered this phase so well that little can be added.

Table VI also illustrates a remarkable similarity between the rheumatic infection of the eastern United States and that of northern California. The cases observed by Coburn, with the exception of carditis, are strikingly comparable with mine. This is a significant fact and, I believe,

TABLE VI

RHEUMATIC INFECTION—TYPES OF ONSET IN 116 PATIENTS

TYPE OF ONSET	OCCURRENCE	PERCENTAGE	COBURN
Arthritis	79	68.1	71.5
Chorea	32	27.5	23.4
Carditis	24	20.6	64.8
Tonsillitis	22	18.9	*
Nodules	12	10.3	13.0
Scarlet fever	9	7.7	7.3
Erythema	7	6.0	17.0
Growing pains	5	4.0	46.8
Extrasystoles	2	1.7	*
Abdominal pain	1	0.8	19.0
Purpura	1	0.8	6.7
Total	194		

*Not noted.

tends to substantiate my suggestion that in San Francisco we deal with a relatively benign type of rheumatic infection, when measured in terms of cardiac damage resulting from the rheumatic infection. This becomes more apparent with study of Table VII when the associated rheumatic manifestations are tabulated and compared with Findlay's figures.[8] This table represents combinations of different rheumatic manifestations and their accompanying carditis. When the problem is approached in this way, the revelation is startling in that with the several combinations noted, carditis is less frequent to a marked degree, although the presence of carditis occurring alone is about the same. The latter fact probably means that the recognition was accurate.

TABLE VII

ASSOCIATED RHEUMATIC MANIFESTATIONS: TYPES OF ONSET ONLY

MANIFESTATION	NUMBER	PERCENTAGE WITH CARDITIS	PERCENTAGE WITH CARDITIS (FINDLAY)
Arthritis	52	13.8	75.1
Arthritis and carditis with growing pains	7		
Arthritis, carditis, and nodules	2		
Arthritis and nodules	4		
Chorea	13	11.1	53.6
Chorea and nodules	3		
Chorea and carditis	1		
Chorea, carditis, and nodules	1		
Arthritis and chorea	11	20.2	69.2
Arthritis, chorea, and carditis	1		
Arthritis, chorea, carditis, and nodules	2		
Arthritis, chorea, and nodules	1		
Carditis	10	9.2	4.1
Total	108		

Rheumatic Infection: Cardiac Lesions—Clinical Frequency in 81 Patients (Table VIII).—Another similarity between the rheumatic infection in San Francisco and elsewhere is illustrated by Tables VIII and IX which reveal the cardiac lesion both when occurring alone and in combination with other lesions of rheumatic fever. The outstanding differences in these tables are in the smaller number of patients who had evidence of mitral insufficiency and mitral stenosis, and in those

TABLE VIII

RHEUMATIC INFECTION: CARDIAC LESIONS—CLINICAL FREQUENCY IN 81 PATIENTS

TYPE OF LESION	PATIENTS	PERCENTAGE	PERCENTAGE (FINDLAY)
Mitral regurgitation	72	88.8	96.8
Mitral stenosis	18	22.2	42.1
Aortic regurgitation	14	17.2	12.0
Pericarditis	10	12.3	14.1
Aortic stenosis	5	6.1	*
Tricuspid insufficiency	1	1.2	*
Total	81		
No demonstrable lesion	35	30.0	3.2
Total patients	116		

*Not noted.

TABLE IX

RHEUMATIC INFECTION: FREQUENCY OF ASSOCIATED VALVULAR LESIONS IN 73 PATIENTS

TYPE OF LESION	NUMBER	PERCENTAGE	PERCENTAGE (FINDLAY)
Mitral regurgitation	42	57.5	45.6
Mitral regurgitation and stenosis	8	10.9	29.2
Mitral regurgitation, stenosis, aortic regurgitation	7	9.5	4.2
Mitral regurgitation, stenosis, aortic regurgitation, pericarditis	1	1.3	1.6
Mitral regurgitation, stenosis, pericarditis	3	4.1	6.1
Mitral regurgitation, pericarditis	6	8.2	3.6
Mitral regurgitation, aortic regurgitation	1	1.3	3.8
Mitral regurgitation, aortic regurgitation, pericarditis	1	1.3	2.0
Mitral stenosis	0	0.0	2.4
Mitral stenosis, aortic regurgitation	0	0.0	0.2
Aortic insufficiency	4	5.4	5.9
Total	73		

which show no demonstrable cardiac pathology when studied by modern methods of clinical and laboratory approach. I realize that the majority of Findlay's cases were studied over a longer period than five years, while the San Francisco series was studied for about two and a half years. This difference in follow-up period partly accounts for the lower percentage of mitral insufficiency, mitral stenosis, and demonstrable cardiac pathology in my tables. However, I believe it is worth noting that with as high a percentage as 30, I am unable to demonstrate clinical or laboratory evidence of cardiac involvement. I realize that though the cards have been shuffled and dealt for this potential cardiac group, the score has not been added. Nevertheless, I present it as further evidence that in San Francisco we deal with a type of rheumatic fever which is of a peculiarly benign nature. I have only suggested the factors influencing this, leaving the truth or fallacy to be decided by further epidemiological study.

Finally, it is also apparent that when the infection does occur, with the exception of the above mentioned mildness, it bears a remarkable similarity to the rheumatic infection elsewhere, as exemplified by family history, age, and seasonal incidence and types of onset and of cardiac involvement.

SUMMARY

A study of rheumatic fever in northern California reveals an unusually high hospital incidence and a low general incidence. A possible explanation which this study of 116 cases in San Francisco brings out is that, while the percentage of cases with no demonstrable cardiac pathology is 30, the incidence of carditis in combination with other rheumatic manifestations is correspondingly low. This suggests that we are dealing with a benign type of rheumatic infection comparable with that of other communicable diseases in California.

In all other respects the rheumatic infection is identical with that seen in the eastern part of the country and in the British Isles.

There was a positive family history for rheumatic fever in 32.4 per cent of this series. The ratio of female to male shows a slight predominance of the former. In chorea the ratio is 2.5 to 1. The peak of the age incidence curve is seven years, and 54.5 per cent of the cases occur between the seventh and tenth years.

In San Francisco the rheumatic infection is a disease which occurs during the first four months of each year. Climatological data are presented which show that in San Francisco December, January, and February are usually the cold and damp months. Types of onset of the rheumatic infection are similar to those of rheumatic fever in the eastern United States. This series includes all the more common types of onset and some of the rarer ones.

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RACIAL DIFFERENCES IN THE INCIDENCE OF CORONARY SCLEROSIS

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STUDIES of the incidence of the various types of heart disease in cities having a relatively large negro population have demonstrated that in the negro both hypertensive heart disease and syphilitic heart disease are far more frequent than in white patients. Schwab and Schulze[1] found that in the negro hypertensive heart disease is two and one-half times more frequent and that syphilitic heart disease is four times as frequent as in white patients. Subsequently they called attention to the fact that in their patients 65 per cent of the negroes with hypertension were under the age of fifty years, whereas in the white patients 65 per cent of the cases occurred after this age.[2] Stone and Vanzant[3] also emphasized the greater incidence of both syphilitic and hypertensive heart disease in the negro, as well as the tendency of the latter disease to occur in negroes much earlier in life.

Sclerosis of the coronary vessels, however, would appear to be less frequent in the negro. Schwab and Schulze[1] found the incidence one and one-half times greater in their white patients, while Stone and Vanzant found the proportion of whites to negroes four to one. The former authors believe that the difference is due to the fact that a smaller number of negroes reach the period of life in which this type of heart disease occurs, and believe that in older negroes the incidence would be higher than in whites. They found no cases of angina pectoris among negroes and offer the same explanation as Roberts,[4] that it is because negroes seem to be less highly organized nervously. It is significant that Stone and Vanzant recorded all patients with high blood pressures among the hypertensive group, while Schwab and Schulze[1] stated that in their cases of arteriosclerotic heart disease the diastolic blood pressure was normal or very slightly elevated, whereas the systolic pressure was constantly high.

From clinical evidence alone, it is frequently impossible to determine in a given patient how much of the cardiac failure is secondary to hypertension, and how much is due to coronary sclerosis. The diagnosis of coronary sclerosis depends to a large extent upon the symptoms of which the patient complains, and these symptoms are notoriously rare in the negro race. It is not surprising, therefore, that this clinical diagnosis should be made less frequently in the negro, especially since the incidence of hypertension is much greater; so that one would expect to find many cases with marked coronary sclerosis classified clinically as cases of hypertensive heart disease.

Since clinical data alone will not suffice to show the relative incidence of coronary sclerosis among negroes and whites, it was thought that a study of autopsy records might give some information on the point in question. A study was made of the clinical and autopsy records of four hundred consecutive autopsies, one hundred each in white males and females and one hundred each in negro males and females, all patients being forty years of age or older, irrespective of the cause of death, in order to determine the presence and degree of sclerosis of the coronary vessels. This method of study cannot be regarded as highly accurate. Nevertheless, since each autopsy record contains a note by two examiners, it was hoped that a fair estimate might be obtained, which would be certainly more accurate than clinical impressions. From the clinical records note was also made of the Wassermann reaction and of the patient's blood pressure. In several cases patients were admitted in shock and died shortly after admission; many of these patients had been followed at intervals in ward and out-patient department for several months or years, and it was possible to obtain accurate information about blood pressure levels. In cases in which such information could not be obtained, however, the pressure levels of these moribund patients were disregarded. Sclerosis of the coronary vessels was graded "0" when there was no sclerosis or only a few yellow flecks of intimal fat deposit; "1" when there was noted moderate streaking with calcium; "2" when sclerosis was well marked but when no narrowing of the lumen of the vessel was present; and "3" when there was marked sclerosis and definite encroachment upon the lumen of either of the vessels. Decrease in the vascular lumen at any point was graded "3," even though the vessels elsewhere might be comparatively free of sclerosis, and the condition of that artery which showed the most advanced changes was taken as the criterion for classification. In cases in which definite evidence of coronary occlusion was present, the degree of sclerosis was, of course, grade 3, and a further note was made of the presence of the occlusion. For the sake of further comparison, patients were divided into two groups according to whether death occurred on a medical or a surgical service.

Tables I to IV show the results obtained in white males, negro males, white females, and negro females, respectively. Comparing the males we find that although there were considerably more negroes from the medical service, the incidence of marked coronary sclerosis among them was 9 per cent and of coronary occlusion 4 per cent (two cases in which the occlusion was old and two in which it was recent and the cause of death), whereas the figures for white males are 24 per cent and 9 per cent, respectively (four cases of old, four cases of recent occlusion, and one case with both an old and a recent occlusion). These differences can hardly be attributed to the slight difference in the average age of the two groups, which is more than compensated by the fact that 68 per cent

of the negro males died on the medical service, compared with 54 per cent of the white males. The larger number of white males from the surgical service would tend to decrease the apparent incidence of coronary sclerosis among the whites, more than among the negro males; thus, of the medical patients alone, the incidence of marked coronary sclerosis is 31.4 per cent for the white males and 12 per cent for the negro males.

TABLE I

WHITE MALES

AGE GROUP	MEDICAL						SURGICAL						TOTAL PATIENTS
	CORONARY SCLEROSIS				OCCLUSION	TOTAL	CORONARY SCLEROSIS				OCCLUSION	TOTAL	
	0	1	2	3			0	1	2	3			
40-44	6	2	0	1	1	9	5	1	0	0	0	6	15
45-49	3	0	1	1	0	5	2	1	1	1	0	5	10
50-54	6	1	0	3	3	10	2	3	4	0	0	9	19
55-59	1	4	0	2	0	7	4	1	0	1	0	6	13
60-64	3	3	1	2	1	9	6	1	0	0	0	7	16
65-69	0	1	1	3	0	5	4	0	0	0	0	4	9
70-74	1	0	0	3	2	4	0	1	1	2	1	4	8
75-79	1	0	0	1	0	2	0	2	0	2	0	4	6
80+	0	1	1	1	0	3	0	0	0	1	1	1	4
Totals	21	12	4	17	7	54	23	10	6	7	2	46	100

Average age: 57.24 years

Average blood pressure: 51 medical patients, $\frac{142.3}{85.1}$; 45 surgical patients, $\frac{147.0}{88.3}$

Average of whole group (96 patients), $\frac{144.5}{86.6}$

Syphilitic aortitis was found post mortem in four of the white males. In two of these cases coronary sclerosis was marked, one of them showing in addition gross myocardial scarring, but there was no evidence that either the coronary narrowing or the myocardial scarring was due to a syphilitic process. In the group of negro males syphilitic aortitis was found post mortem in twenty-eight cases. In four of these cases the orifices of the coronary arteries were markedly narrowed by the process in the aorta. Three of these showed slight and the fourth moderate coronary sclerosis in addition; they are so recorded in Table II in spite of the actual stenosis caused by the syphilitic process.

It is a well-established fact that coronary disease is less frequent in women than in men, and a comparison of Tables I and III shows only what one might expect if the method of study is reasonably accurate. Thus, in the present series, marked sclerosis was noted in 24 per cent of the white males and in 10 per cent of the white females; the figures for coronary occlusion are 7 per cent and 4 per cent, respectively. Comparing the white females with the negro males, however, we find that the incidence of coronary disease is about the same, being 10 per cent for the white females and 9 per cent for the negro males. Table IV would seem to indicate that there is the same sex difference in the incidence of

TABLE II

NEGRO MALES

AGE GROUP	MEDICAL						SURGICAL						TOTAL PATIENTS
	CORONARY SCLEROSIS				OCCLUSION 1 RECENT 2 OLD	TOTAL	CORONARY SCLEROSIS				OCCLUSION	TOTAL	
	0	1	2	3			0	1	2	3			
40-44	7	3	1	0	0	11	8	0	0	0	0	8	19
45-49	11	2	1	3	1	17	4	1	0	0	0	5	22
50-54	4	5	0	3	2	12	2	0	0	0	0	2	14
55-59	10	2	1	1	0	14	4	0	2	0	0	6	20
60-64	6	1	1	0	0	8	0	1	0	0	0	1	9
65-69	1	2	0	0	0	4	1	1	0	0	0	2	6
70-74	0	1	0	0	0	1	0	2	3	0	0	5	6
75-79	1	0	0	0	0	1	1	1	0	1	1	3	4
Totals	40	16	4	8	3	68	20	6	5	1	1	32	100

Average age: 53.82 years

Average blood pressure: 63 medical, $\frac{162.2}{95.2}$; 28 surgical, $\frac{156.7}{86.7}$

Average of whole group (91 patients), $\frac{160.5}{92.6}$

TABLE III

WHITE FEMALES

AGE GROUP	MEDICAL						SURGICAL						TOTAL PATIENTS
	CORONARY SCLEROSIS				OCCLUSION 3 RECENT 1 OLD	TOTAL	CORONARY SCLEROSIS				OCCLUSION	TOTAL	
	0	1	2	3			0	1	2	3			
40-44	6	1	3	0	0	10	3	1	0	0	0	4	14
45-49	4	1	0	0	0	5	8	2	0	0	0	10	15
50-54	7	1	1	1	1	10	5	0	0	0	0	5	15
55-59	8	2	0	0	0	10	1	2	0	0	0	3	13
60-64	2	3	1	2	1	8	6	0	0	0	0	6	14
65-69	0	0	6	2	1	8	0	3	0	0	0	3	11
70-74	2	1	1	5	1	9	3	0	0	0	0	3	12
75-79	0	1	1	0	0	2	0	0	1	0	0	1	3
80+	0	1	0	0	0	1	1	1	0	0	0	2	3
Totals	29	11	13	10	4	63	27	9	1	0	0	37	100

Average age: 57.58 years

Average blood pressure: 59 medical, $\frac{161.1}{90.6}$; 33 surgical, $\frac{139.8}{81.6}$

Average of whole group (92 patients), $\frac{153.5}{87.4}$

coronary disease among negroes as among whites and that negro females are accordingly less susceptible to coronary sclerosis than are any of the other three groups studied. Table V summarizes the results obtained in the study of the four groups.

The age distribution in the various groups may account for some of the differences noted in the incidence of coronary disease. The average

TABLE IV

NEGRO FEMALES

AGE GROUP	MEDICAL						SURGICAL						TOTAL PATIENTS
	CORONARY SCLEROSIS				OCCLUSION 1 RECENT 1 OLD	TOTAL	CORONARY SCLEROSIS				OCCLUSION	TOTAL	
	0	1	2	3			0	1	2	3			
40-44	14	1	0	0	0	15	16	1	2	0	0	19	34
45-49	16	3	1	0	0	20	7	3	0	0	0	10	30
50-54	4	0	0	1	0	5	3	2	1	0	0	6	11
55-59	4	3	3	0	0	10	3	1	0	0	0	4	14
60-64	0	3	0	1	0	4	3	0	0	0	0	3	7
65-69	0	2	0	1	1	3	0	0	0	0	0	0	3
70-74	0	0	0	1	1	1	0	0	0	0	0	0	1
Totals	38	12	4	4	2	58	32	7	3	0	0	42	100

Average age: 48.78 years

Average blood pressure: 56 medical patients, $\frac{172.7}{99.1}$; 36 surgical patients, $\frac{149.9}{89.3}$

Average of whole group (92 patients), $\frac{163.8}{95.3}$

age of the white males and females (57.24 and 57.58 years, respectively) is about the same, but the average age of the negro males (53.82 years) is approximately three and one-half years less, and of the negro females a full eight and one-half years less than that of the white males. One must also consider the fact that all of the negroes were public ward patients, whereas a certain proportion of the white patients were from the private wards; and, since coronary sclerosis is believed to be more frequent among the so-called "upper walks" of life, it is possible that the differences noted in the incidence of the disease are due to occupational rather than racial factors.

TABLE V

	MARKED CORONARY SCLEROSIS	OCCLUSION	SYPHILITIC AORTITIS	AVERAGE AGE, YEARS
White males—100	24	9	4	57.2
Negro males—100	9	4	28	53.8
White females—100	10	4	1	57.6
Negro females—100	4	2	12	48.8

Although the evidence herein presented is not entirely conclusive, it at least indicates that there may be definite differences in the incidence of coronary disease between members of the white and of the negro races. The etiological factors in the production of coronary disease are at present poorly understood; if faulty hygiene has any bearing upon the subject, one would expect the negro to be much the more susceptible.

SUMMARY

A study of the autopsy records of four hundred patients above the age of thirty-nine years showed the incidence of marked coronary sclerosis to be 24 per cent for white males, 9 per cent for negro males, 10 per cent for white females, and 4 per cent for negro females.

Coronary occlusion with myocardial infarction, either recent or old, was found in 9 per cent of the white males, 4 per cent of the negro males, 4 per cent of the white females, and 2 per cent of the negro females.

The evidence suggests that members of the white race are much more susceptible to coronary sclerosis than are negroes.

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STUDIES ON EXPERIMENTAL CORONARY OCCLUSION*†

Chemical and Anatomical Changes in the Myocardium After Coronary Ligation

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THE experiments herewith recorded were designed to correlate histological and chemical changes in the myocardium as these are affected by permanent or temporary ligation of the coronary vessels. The chemical studies deal with the determination of the glycogen and lactic acid content of the muscle.

Preliminary reports from this laboratory have dealt with surface temperature[1] and chemical[2] changes in the myocardium, and electrocardiographic configurations[3] after ligation of the coronary vessels. Immediately after the ligation of the descending ramus of the left coronary artery the temperature of the affected muscle, measured by thermocouples and a Leeds & Northrop potentiometer recording system, dropped from 2 to 8° F. below the level of the muscle with its circulation intact, and with release of the ligature the temperature rose promptly to its former level. It was also shown that vagotomy, bilateral stellate ganglionectomy, stimulation of the vagi or of the sympathetic fibers to the heart had no effect on these temperature changes. The results indicate that, with the sudden deprivation of the blood supply, no immediate collateral circulation to the affected myocardium is developed.

METHODS

Dogs weighing from 15 to 20 kilograms were anesthetized with sodium amytal and, under mild artificial respiration, the hearts were exposed either by resection of the fourth left rib or by a simple incision through the fourth left interspace. The anterior descending branch of the left coronary artery with its accompanying veins was ligated within 2 cm. of its origin. The pericardium and chest wall were then tightly closed and were reopened only to remove tissue for chemical analysis. The samples of tissue were excised from the beating heart in situ in the living animal and plunged immediately into liquid air; this procedure required not more than 15 seconds. Samples of tissue were removed from the zone supplied by the ligated vessels and from a control zone, the right ventricle, and were analyzed either for lactic acid or glycogen. About 2 gm. of tissue were employed for each determination. The frozen tissue was fragmented and put into weighing bottles containing sulphuric acid for lactic acid determinations by the method of Friedemann and Graeser.[4] For the glycogen determination the fragmented frozen tissue was placed in 50 c.c. centrifuge tubes containing 5 c.c. of 60 per cent potassium

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hydroxide. The hydrolysis was carried out by the modified Pflüger method as outlined by Yannet and Darrow,[5] and the glucose content was determined in aliquots by Somogyi's modification of the Shaffer-Hartman sugar method.

Immediately after the termination of the experiments the hearts were examined for gross changes in consistency and appearance of the myocardium, and the coronary arteries were carefully explored to determine whether the vessels were securely ligated or patent in the instances where the circulation was reestablished. Blocks of tissue were taken from the zone supplied by the ligated vessels as well as from the right ventricle, and these were fixed in 4 per cent formaldehyde and Zenker's fluid. Sections were stained with hematoxylin and eosin, phosphotungstic acid hematoxylin, Mallory's aniline blue connective tissue stain, and sudan III.

EXPERIMENTAL DATA

Chemical and Anatomical Changes After Ligation of Coronary Vessels.—In this group of experiments the anatomical changes were correlated with the lactic acid or the glycogen changes in the myocardium of dogs whose coronary vessels had been ligated for periods ranging from one-half hour to twenty-four hours.

The lactic acid content of the muscle tissue from the zones supplied by the ligated vessels was strikingly increased in all instances as compared to that of the control zone (Table I). In contrast, the glycogen content was decreased in all instances in the muscle tissue from the zone supplied by the ligated vessels (Table II). Control animals subjected to the same surgical procedures but in whom the sutures were merely passed about the coronary vessels and then removed showed no significant variation in the lactic acid or glycogen content of the muscle tissue from the two zones.

TABLE I

LACTIC ACID CONTENT OF HEART MUSCLE AFTER LIGATION OF CORONARY VESSELS

DOG NO.	NO. OF HR. LIGATED	LACTIC ACID AV. MG. /100 GR. OF TISSUE	
		INVOLVED ZONE	UNINVOLVED ZONE
45	½	149.5	47.5
44	4	103.5	58.0
42	10	96.5	54.0
43	24	97.8	61.8
46	24 (Control)	51	51.3

TABLE II

GLYCOGEN CONTENT OF HEART MUSCLE AFTER LIGATION OF CORONARY VESSELS

DOG NO.	NO. OF HR. LIGATED	GLYCOGEN AS GLUCOSE AV. MG. /100 GR. OF TISSUE	
		INVOLVED ZONE	UNINVOLVED ZONE
47	2	503.0	826.0
75	4	296.0	1051.5
53	8	354.0	1410.0
51	24	490.5	1142.0
54	24 (Control)	958.5	938

The histological changes in the myocardium with occlusion of the coronary vessels varied with the period of ligation. They may be divided into two main groups, the first includes the first forty-eight-hour period when the necrotizing and exudative processes predominate, and the second, longer periods associated with the appearance of the reparative processes (Table V).

The earliest histological changes in the myocardium were seen in the preparations from dogs killed eight hours after ligation of the coronary vessels, and consisted of edema of the interstitial tissue and fat droplets in the cytoplasm of the myocardial fibers. In the preparations from dogs killed twenty-eight hours after ligation, necrosis of the myocardial fibers was observed, together with an increase in the fat in the cytoplasm of the cells and a polymorphonuclear cellular exudate and red blood cell infiltration throughout the interstitial tissues. After forty-eight hours of ligation the same extensive necrotizing and exudative process was present; and in addition, occasional fibroblasts were seen extending out from the adventitia of the blood vessels adjacent to the necrotic muscle fibers. Four days after ligation the connective tissue proliferation was more extensive; masses of necrotic muscle fibers were now surrounded by fibroblasts. From this period on, the reparative process became dominant, and at the end of a month the infarcted zone was completely replaced by a dense fibrous tissue scar, which was infiltrated with small mononuclear cells and large phagocytic cells containing golden brown pigment.

The histological changes observed here were similar to those described in detail by Karsner and Dwyer[6] in their studies of experimental infarction of the myocardium in dogs.

Ligation of Coronary Vessels With Subsequent Release of Ligatures.—In these experiments the coronary vessels were ligated for varying periods up to eight hours; the ligatures were then released and two hours later tissues were removed from the myocardium for chemical and anatomical study.

In all instances except one, the lactic acid content of the muscle from the zone supplied by the previously ligated vessels was slightly but not appreciably lower than that of the muscle from the control zone. In the one exception, Dog 59, the anterior descending branch of the left coronary artery was found occluded at autopsy by a freshly formed thrombus (Table III). The glycogen content of the affected muscle in contrast remained decreased below that of the control zone as in the first group of experiments (Table IV).

Striking anatomical changes were noted in the myocardium supplied by the previously ligated vessels except in the instance where the vessel was tied for only one-half hour, in which case no demonstrable changes were seen. In the other hearts the myocardium supplied by the previously ligated vessels was the seat of an extensive hemorrhagic infarct

which extended throughout the entire thickness of the wall, involving intensely the inner half and also the anterior one-third of the interventricular septum (Table V).

TABLE III

LACTIC ACID CONTENT OF HEART MUSCLE TWO HOURS AFTER UNTYING LIGATED VESSELS

DOG NO.	NO. OF HR. BET. LIGATION AND UNTYING OF ARTERY	LACTIC ACID AV. MG. /100 GR. OF TISSUE	
		INVOLVED ZONE	UNINVOLVED ZONE
67	½	38.8	54.3
65	2	39.5	65.3
59	4	78.5	71.3
60	8	52.0	66.0

TABLE IV

GLYCOGEN CONTENT OF HEART MUSCLE TWO HOURS AFTER UNTYING LIGATED VESSELS

DOG NO.	NO. OF HR. BET. LIGATION AND UNTYING OF ARTERY	GLYCOGEN AS GLUCOSE AV. MG. /100 GR. OF TISSUE	
		INVOLVED ZONE	UNINVOLVED ZONE
81	2	158.5	528.5
68	8	281.0	757.5

TABLE V

ANATOMIC CHANGES IN THE MYOCARDIUM FOLLOWING LIGATION OF CORONARY VESSELS

DOG NO.	TIME LIGATED	MYOCARDIUM									
		EXUDATE		HEMORRHAGE		FAT		NECROSIS		FIBROSIS	
		EXP.	CON.	EXP.	CON.	EXP.	CON.	EXP.	CON.	EXP.	CON.
9	1 hr.	0	0	0	0	0	0	0	0	0	0
6	2 hr.	0	0	0	0	0	0	0	0	0	0
4	2½ hr.	0	0	0	0	0	0	0	0	0	0
5	4 hr.	0	0	0	0	0	0	0	0	0	0
8	7 hr.	0	0	0	0	0	0	0	0	0	0
10	7½ hr.	+	0	0	0	+	0	0	0	0	0
2	9 hr.	+	0	0	+	0	0	0	0	0	0
25	12 hr.	E*	0	+	0	+	+	±	0	0	0
22	16 hr.	E	0	0	0	++	0	0	0	0	0
29	28 hr.	+++E	0	0	0	++	+	++	0	0	0
30	30 hr.	+E	0	+	0	++	+	+	0	0	0
28	35 hr.	+E	0	+	0	+	0	+	0	0	0
16	2 days	++	0	0	+	+++	0	++	0	0	0
15	4 days	+++	0	0	0	+++	0	+++	0	early	0
34	33 days	0	0	0	0	0	0	0	0	+++	0
24	48 days	0	0	0	0	0		0	0	+++	0
20	72 days	0	0	0	0	0	0	0	0	+++	0
26 (con)	74 days	0	0	0	0	0	0	0	0	0	0
	CIRCULATION REESTABLISHED FOR TWO HOURS										
67	½ hr.	E	0	0	0	0	0	0	0	0	0
65	2 hr.	+E	0	+++	0	0	0	+	0	0	0
81	2 hr.	+E	0	+++	0	0	0	+	0	0	0
59	4 hr.	+E	0	+++	0	0	0	+	0	0	0
60	8 hr.	+E	0	+++	0	0	0	+	0	0	0
68	8 hr.	++E	0	+++	0	0	0	+	0	0	0

*E, edema.

DISCUSSION

It is apparent from the data on the first group of experiments (Tables I and II) that the accumulated lactic acid in the ischemic myocardium results from the glycogen breakdown. In the normal heart excessive lactic acid formation is prevented by the large amount of oxygen furnished through an abundant blood supply, an amount much greater than that for an equal weight of skeletal muscle (Himwich and Castle[7]), Markwalder and Starling[8]). Indeed, it has been shown that the functioning heart with its circulation intact does not pour out lactic acid into the blood stream, but actually removes it from the circulating blood (Himwich,[9] McGinty[10]). McGinty has further shown that in instances where the blood supply to the myocardium of the intact heart is reduced by vasoconstriction following large doses of pitressin, a pouring out of lactic acid from the heart into the blood stream occurs. Associated with the vasoconstriction apparently, there is a marked degree of anoxia so that lactic acid forms and accumulates to such an extent that it diffuses into the circulation. In the present experiments the muscle in the zones supplied by the ligated vessels is functioning under conditions of extreme anoxia and accordingly utilizes its stored glycogen; with the lack of circulation in the part, lactic acid accumulates. Similar chemical changes in the affected myocardium following experimental ligation of the coronary artery in dogs have been reported by Pomodoro[11] and Himwich and his associates.[12]

In the second group of experiments in which the ligatures were subsequently removed, the lactic acid content of the myocardium in the involved zone fell below that of the control zone. Apparently, the accumulated lactic acid was washed out by the reestablishment of blood flow. That this drop was not due to a resynthesis of the lactic acid to glycogen is evidenced by the fact that the latter remained at the same low level as in the first group in which the circulation was not restored.

The absence of any demonstrable anatomical changes in the muscle tissue until eight hours after ligation was in striking contrast to the findings when the circulation was restored by the removal of the ligatures. Under the latter condition extensive hemorrhage, edema, and polymorphonuclear leucocytic exudate was present throughout the involved zones, even when the interval of ligation was only two hours. This exudative reaction indicates at least that alteration of the capillary walls has taken place. The failure of glycogen resynthesis following reestablishment of the circulation suggests that injury to the myocardial fibers themselves also may have occurred even though this was not histologically demonstrated. The lack of early exudative changes when the circulation has not been reestablished may be attributable to the absence of blood flow through the part.

SUMMARY

1. Occlusion of the left anterior descending coronary artery and accompanying veins results in an increase of the lactic acid and a decrease of glycogen content of the muscle deprived of its circulation.

2. When the circulation is reestablished for two hours by release of the ligatures after varying intervals of occlusion, the lactic acid content of the affected muscle returns to normal, but restoration of the glycogen content does not occur.

3. When the circulation is restored in the myocardium by release of the ligature, a series of changes is observed histologically that contrast with the usual picture of experimental infarction.

These experiments were planned and carried out during 1932-1934 under the direction of Dr. Raymond Hussey.

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A STUDY OF THE VARIATIONS OF THE RS-T SEGMENT IN EXPERIMENTAL VENTRICULAR TRAUMA*

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ALTHOUGH considerable evidence has been presented concerning the significance and classification of the RS-T changes associated with cardiac infarction, no attempt has been made to explain or to evaluate the mechanisms responsible for the production of these characteristic electrocardiographic alterations when specific areas of the heart are injured. Subsequent to Parkinson and Bedford's presentation[1] of their classification of T_1 and T_3 types of curves, most of the experimental and clinical work on this subject has been utilized to obtain a purely arbitrary correlation of the location of infarcts with the electrocardiographic variations (see Barnes[2] for review). The evidence on this point has been conflicting; some of the workers, in fact, consider the conclusions evolved therefrom to be based merely upon fortuitous findings.[3, 4]

While much work has been done on the relationship of the direction of the main deflection of the extrasystolic curve to the point of stimulation in the ventricles, more specific data were presented in a recent paper by Abramson and Weinstein.[5] They noted that the direction of the initial complex of experimental ventricular extrasystoles, recorded with the three standard leads, depended upon the relative position of the point of stimulation in the mass of ventricular muscle and upon the particular orientation of the point and muscle mass to the recording lines of the leads. It is known that the electrical changes produced by stimulation and by injury of tissue have in common the development of negativity at the site of application (the only main differences being the magnitude and duration of the effect produced in each case). Accordingly, it was thought that possibly the same relationship that exists between the location of the point of origin of the extrasystole and the direction of its recorded main deflection might also exist between the site of myocardial trauma and the resulting characteristic electrocardiographic variations. Therefore, this study was undertaken to compare electrocardiographic effects of stimulation of various portions of the cat's ventricles with those of cauterization of the same areas. In this way it was hoped some light might be cast on the fundamental factors responsible for the form and type of RS-T changes, and on how they are influenced by the anatomical location of the injured area.

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METHOD

The experiments reported below were performed on thirteen cats under dial anesthesia, injected intraperitoneally. Artificial respiration was instituted, the heart exposed by making a U-shaped flap of the anterior chest wall, and then the pericardium was slit. Control electrocardiograms, using the three standard leads, were recorded before and after these operative procedures. After numerous trials, it was found that the most constant results were obtained by studying the following six sites (Fig. 1): (1) Anterior surface of the right ventricle; (2) anterior aspect of the interventricular septum with the boundaries extending onto both ventricles; (3) left ventricle anteriorly at the base; (4) left ventricle anteriorly at the apex; (5) left ventricle posteriorly; (6) right ventricle posteriorly.

The ventricles were stimulated by means of an electrode composed of two fine steel wires, encased in a bent glass tube and insulated with sealing wax. The electrode was connected to the binding posts of the secondary coil of an inductorium, and the primary circuit was broken at a rate slightly above the sinus beat by means of a Harvard spring interrupter. Records of extrasystoles were obtained from each of the selected areas, special attention being paid to the one region subse-

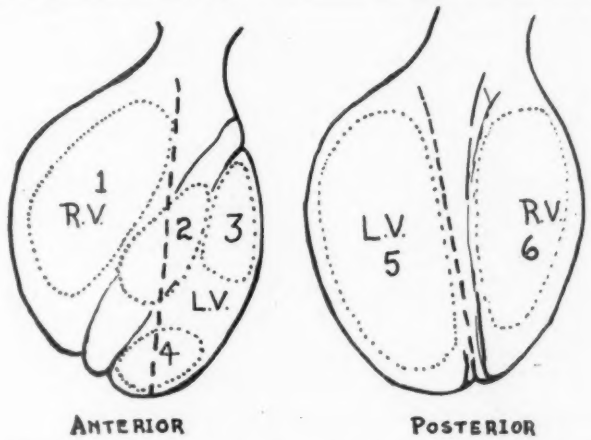

Fig. 1.—Schematic drawings of anterior and posterior surfaces of the ventricle. The six areas enclosed by the dotted lines represent the ones studied: *1*, right ventricle anteriorly; *2*, anterior aspect of interventricular septum; *3*, basal portion of left ventricle anteriorly; *4*, apical portion of left ventricle anteriorly; *5*, posterior surface of left ventricle; *6*, posterior surface of right ventricle. The broken lines on both drawings represent the line of transition for Lead I.

quently to be cauterized. In the case of the latter, stimuli were applied to a number of additional points at the periphery and in the center of this site. An area of injury was produced in this previously outlined site by means of an electric cautery, following the procedure of Crawford and his associates.[6] The size of the injury was generally about 1.5 cm. in diameter and extended for about a millimeter into the myocardium. In all instances, care was taken to limit the cauterization to that part of the heart under study at the moment. Electrocardiograms were obtained immediately after the injury, first with the normal sinus rhythm, and then with a repetition of stimulation of all six of the designated areas. Following the production of the extrasystoles, a control record was again obtained to make certain that the RS-T alteration produced by the cauterization was still present. In a number of experiments, after the electrocardiographic effects consequent to cauterization had entirely disappeared, a second area was studied. At times, when the site of injury was located on the anterior surface of the heart, it was found necessary, in order to bring out more clearly the resulting electrocar-

diographic alterations, to apply a pad of cotton dipped in warm saline to the anterior surface of the heart and to cover this with the chest flap. This difference in technic required in the case of the anterior heart surface may be attributed to the reduction in conductivity of the action currents from the heart due to the removal of the anterior chest wall (in contrast to the posterior surface which retains essentially its normal relationship to the surrounding tissues). Wood and Wolferth[7] found a similar difficulty in obtaining electrocardiographic changes following ligation of the anterior descending branch of the left coronary artery, unless they worked with very little of the heart exposed.

In order to test the effect of rotation of the heart on the curve produced by injury at a particular point, the following procedure was carried out in certain experiments: Stay sutures were sewed into the epicardium of the ventricles, one at the apex of the heart and one at each lateral surface. By means of these, the heart was made to rotate to the right or left on its long axis, and electrocardiograms obtained in each position and finally after return to the normal position. Control electrocardiograms were taken in some cases with the heart displaced as described but without any injury by cauterization. The effect on the RS-T interval in these controls was, for the most part, negligible.

Generally the tension of the string was such that the introduction of 1 mv produced a deflection of 1.5 cm., except when the extrasystolic waves were recorded, in which case the usual relationship of 1 mv to 1 cm. deflection existed.

RESULTS

For the sake of convenience in recording, the electrocardiographic findings obtained with artificial stimulation and with cauterization are incorporated in Table I, and only explanatory notes and a summation of

TABLE I

EFFECT OF STIMULATION AND SUBSEQUENT CAUTERIZATION OF SITES ON THE EPICARDIAL SURFACE OF BOTH VENTRICLES

SITE STUDIED	CAT NO.	DIRECTION OF INITIAL DEFLECTION OF EXTRASYSTOLIC WAVE			DIRECTION OF RS-T SEGMENT SUBSEQUENT TO CAUTERIZATION		
		LEAD I	LEAD II	LEAD III	LEAD I	LEAD II	LEAD III
Right ventricle anteriorly	4	+	+	+	0	−	−
	8	+	+	+	0	=	=
	7	+	+	+	−	−	−
Anterior surface over septum	6	±	+	+	+	=	=
	12	±	+	+	+	=	=
Left ventricle anteriorly at base	11				+	=	=
	15	−	+	+	+	−	−
	16	−	+	+	+	=	=
Left ventricle anteriorly at apex	3A	−	−	−	+	+	0
	14	±	−	−	+	++	++
	13A	−	−	−	−	++	++
Left ventricle posterior surface	2	−	−	−	+	+	+
	3B	−	−	−	+	+	+
	5A	−	−	−	+	++	++
	9	−	−	−	+	++	++
	13B	−	−	−	0	++	++
Right ventricle posterior surface	1	+	−	−	0	+	+
	5B	+	−	−	−	++	++
	10	+	−	−	−	++	++

+ Indicates a positive deflection.
− Indicates a negative deflection.
The number of these indicates grossly the relative amplitude of the waves.
0 Represents no change in RS-T segment following cauterization.

results are given herewith. The presentation of the data is limited to listing, first, the direction of the initial deflection of the extrasystolic wave obtained from stimulation of a specific area and, second, the direction of the deviation of the RS-T segment with normal sinus rhythm, following cauterization in the same site. In the instances in which the direction of the initial deflection of the extrasystolic complexes obtained from the center and from the periphery of the site under study varied, the one selected for tabulation represents the most common and characteristic finding.

In the case of Lead I, it was noted that generally, with normal sinus rhythm, the amplitude of the waves was small, so that the effect of cauterization on the RS-T segment in some instances was insignificant.

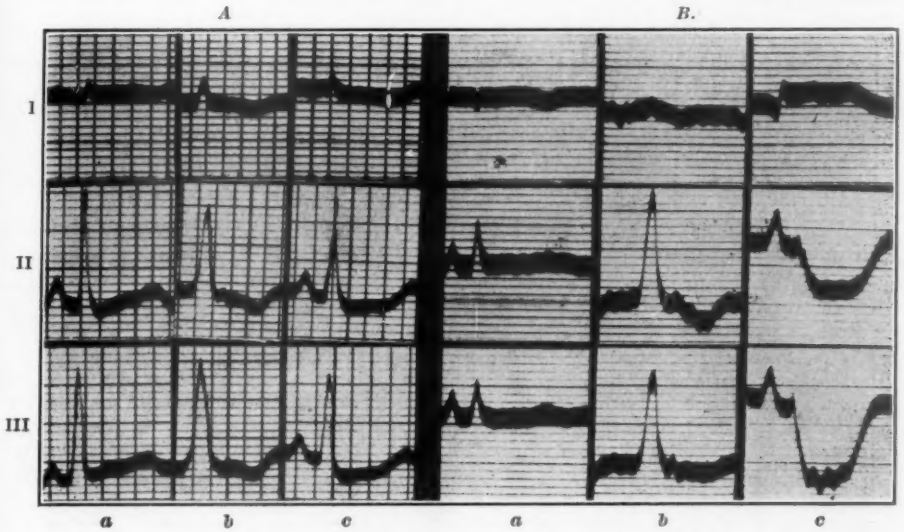

Fig. 2.—*A*, Experiment 16, anterior surface of right ventricle: *a*, control with normal sinus rhythm; *b*, extrasystolic waves obtained upon stimulation of this site. Initial deflection upright in all three leads. *c*, curves obtained with normal sinus rhythm after cauterization in the same area. Depression of RS-T in all three leads.

B, Experiment 6, anterior surface of septum including contiguous portions of both ventricles: *a*, control with normal sinus rhythm; *b*, extrasystolic waves obtained by stimulation at this site. Initial deflection in Lead I almost isoelectric and in the other two leads upright. *c*, curves obtained with normal sinus rhythm after cauterization in the same area. Elevation of RS-T in Lead I and depression in the other two.

Time, 1/25 second; 1 mv = 1.5 cm. for curves obtained with sinus rhythm. 1 mv = 1 cm. for curves obtained by artificial stimulation.

On the other hand, the changes in Leads II and III were consistently marked, in some cases being of such magnitude as to hide the R- and T-waves completely.

Comparison of the Direction of the RS-T Alterations With the Direction of the Main Deflections of the Extrasystolic Waves.—From an examination of Table I it will be seen that in Lead I the direction of the RS-T segment following cauterization appears to depend upon whether the damage was situated grossly on the right or the left ventricle, i.e.,

the direction of the RS-T segment was consistently negative in instances of cauterization on the right ventricle (Figs. 2*A* and 4*A*) and positive in instances of cauterization of the left ventricle (Figs. 3*A* and *B* and 4*B*). The only exceptions were the four cases in which no change was observed (Experiments 1, 4, 8, and 13*B*) and the one case (Experiment 13*A*) in which injury to the left ventricle anteriorly at the apex produced an RS-T depression. In those experiments in which the trauma extended onto both ventricles (Experiments 6 and 12) the direction of the RS-T segment was similar to that obtained on the left ventricle (Fig. 2*B*).

The changes in Leads II and II were generally alike. In all instances of cauterization on the anterior surface of the heart (except the left ventricle at the apex) the RS-T segment was depressed in both leads

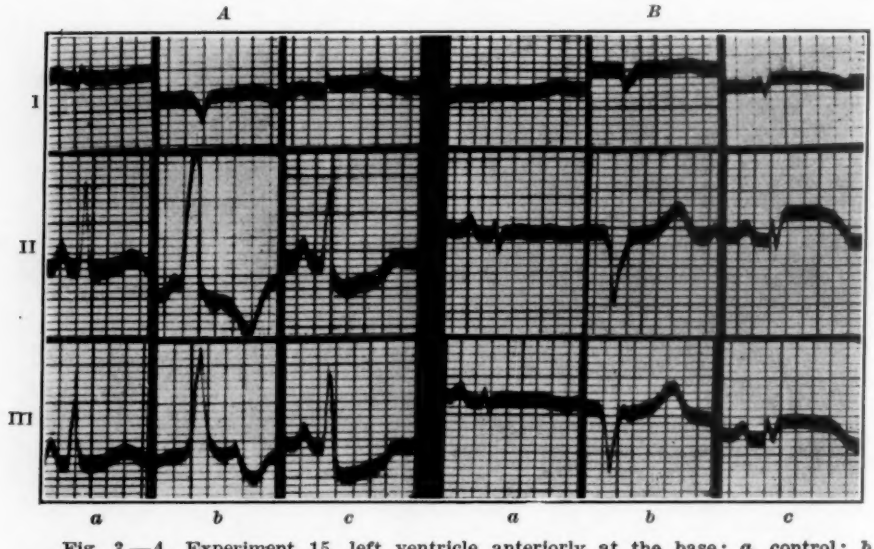

Fig. 3.—*A*, Experiment 15, left ventricle anteriorly at the base; *a*, control; *b*, extrasystolic waves obtained by stimulation of this site. Main deflection negative for Lead I and positive for the other two leads. *c*, curves with normal sinus rhythm after cauterization in the same area. Elevation of RS-T in Lead I and depression in the other two leads.

B, Experiment 14, left ventricle anteriorly at the apex: *a*, control; *b*, extrasystolic waves obtained by stimulation of this site. Main deflection negative in all three leads. *c*, curves with normal sinus rhythm after cauterization in the same area. Elevation of RS-T in all three leads.

(Figs. 2*A*, 2*B*, and 3*A*). For the entire posterior surface of the heart, either right or left ventricle, as well as for the left ventricle anteriorly at the apex, the direction of the RS-T segment was consistently positive in both leads (Figs. 3*B*, 4*A*, and 4*B*).

In reference to the direction of the initial deflection of extrasystolic waves, the results were essentially similar to those obtained by Abramson and Weinstein. In Lead I the initial complex was upwardly directed for points of stimulation to the right of the lines of transition on both surfaces (Figs. 2*A* and 4*A*), and downwardly directed for com-

parable areas to the left of it (Figs. 3*A*, 3*B*, and 4*B*). These lines of transition for Lead I grossly followed the location and direction of the interventricular grooves on both surfaces except that the anterior one in its upper portion extended somewhat on to the right ventricle, and in its lower third obliquely onto the apex of the left ventricle* (Fig. 1).

The types of extrasystolic waves obtained in Leads II and III were alike grossly; the initial deflection was positive in cases of stimulation of points on the anterior surface of the heart (Figs. 2*A*, 2*B*, and 3*A*), except for the inferior portion of the left ventricle anteriorly. From the latter region and from the entire posterior surface of both the right and left ventricles, the main initial deflection in Leads II and III was downwardly directed (Figs. 3*B*, 4*A*, and 4*B*).

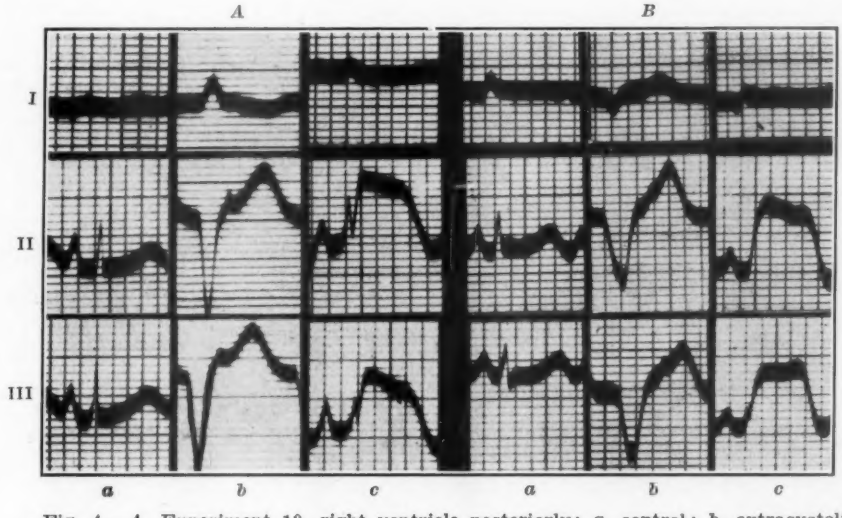

Fig. 4.—*A*, Experiment 10, right ventricle posteriorly: *a*, control; *b*, extrasystolic waves obtained by stimulation of this site. Main deflection positive for Lead I and negative for the other two leads. *c*, curves with normal sinus rhythm after cauterization in the same site. Slight depression of RS-T in Lead I and marked elevation in the other two leads.

B, Experiment 9, left ventricle posteriorly: *a*, control; *b*, extrasystolic waves obtained by stimulation of this site. Main deflection negative for all three leads. *c*, curves with normal sinus rhythm after cauterization in the same site. Slight elevation of RS-T segment in Lead I and marked elevations in the other two leads.

It is therefore apparent from the above that the same factors which affect the direction of the initial deflection of extrasystolic waves also influence the direction of the displacement of the RS-T interval following cauterization. Moreover, in all instances, cauterization of an area from which extrasystolic waves had previously been elicited resulted in an RS-T change which was consistently opposite in phase to the chief initial deflection of the extrasystole. (Figs. 2, 3, and 4.) Such

*This may explain why in an experiment (Experiment 13A) in which the apex of the left ventricle, anteriorly, was cauterized, a right ventricular effect was recorded, i.e., an RS-T depression in Lead I. The damage probably extended somewhat to the right of the line of transition.

constancy of results would appear to place these findings beyond the realms of mere coincidence. This relationship between portions of curves apparently having no common denominator will be given significance in a later paper in which the theoretical basis for the observed changes will be discussed.[8]

Effect of Rotation of the Heart upon the RS-T Alteration.—It has been shown[5] that stimulation of the right side of the ventricular mass results in an upward chief initial deflection in Lead I. This is so whether the right side of the ventricular mass, as in the normally placed heart, is predominantly right ventricle or whether the heart is so rotated that the left ventricle becomes the right side of the ventricular mass and it then receives the stimulus.

In order to determine whether an alteration in the position of the site of cauterization relative to the recording lead lines also produces a change in the type of RS-T deflection, and whether a correlation exists comparable to that obtained with extrasystoles,[5] the heart was rotated on its long axis immediately after injury, in a number of experiments. By means of stay sutures it was turned either to the right, so that a

TABLE II

EFFECT OF ROTATION OF HEART ON THE RS-T ALTERATION SUBSEQUENT TO CAUTERIZATION

SITE OF LESION	CAT NO.	ORIGINAL RS-T SEGMENT			NEW SITE OF LESION	SUBSEQUENT RS-T SEGMENT		
		LEAD I	LEAD II	LEAD III		LEAD I	LEAD II	LEAD III
Rotation to the Right So as to Expose More of the Left Ventricle Anteriorly								
Right ventricle anteriorly	16	−	−	−	Posteriorly and on right side	−	+	+
Anterior surface of septum	12	+	=	=	Posteriorly and to the right	−	++	++
Left ventricle anteriorly	15	+	−	−	Laterally and to the right	−	−	0
Left ventricle posteriorly	2	++	++	++	Anteriorly and to the left	++	=	=
Right ventricle posteriorly	10	−	++	++	Anteriorly and to the left	+	0	−
Rotation to the Left So That Anterior Surface of Heart Is Made Up Entirely of Right Ventricle								
Anterior surface of septum	12	+	−	−	Laterally and to the left	+	0	−
Left ventricle anteriorly	15	+	−	−	Posteriorly and to the left	+	+	0
Right ventricle anteriorly	16	−	−	−	Laterally and to the left	+	−	−
Left ventricle posteriorly	5	0	+	+	Posteriorly and to the right	0	+	+
Right ventricle posteriorly	10	−	++	++	Anteriorly and to the left	++	=	=

+ Indicates a positive direction.
− Indicates a negative direction.
The number of these indicates grossly the relative magnitude of RS-T change.
0 Represents no RS-T alteration.

greater part of the left ventricle presented anteriorly, or to the left so that the entire anterior surface of the heart was made up of right ventricle. It will be noted from Table II that, when the position of the injury was changed by these manipulations from a posterior to an anterior position, or vice versa, the direction of the RS-T deflection in Leads II and III became reversed (Fig. 5*A* and *B*). For example, if a heart in which the anterior surface of the intraventricular septum had been cauterized, resulting in a depression of the RS-T segment in Leads II and III, was now rotated so that the injured portion was situated posteriorly, a definite elevation of the RS-T segment in these leads was noticed (Fig. 5*B*). If the position of the heart was so changed that trauma to the left of the hypothetical line of demarcation for Lead I was changed to the right of it, or vice versa, a definite reversal in the

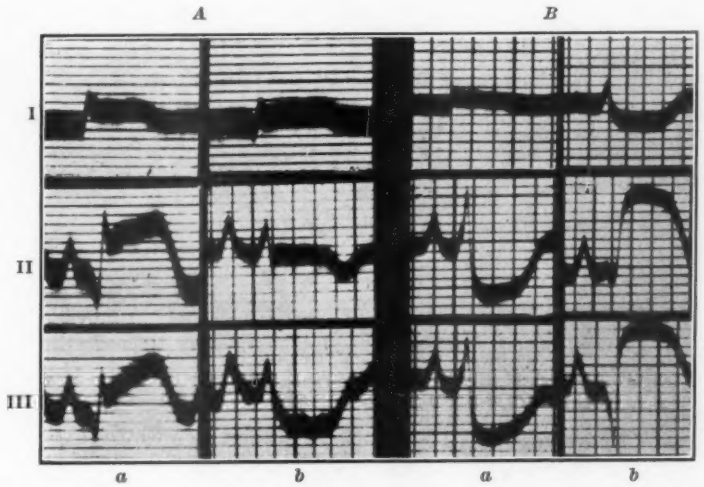

Fig. 5.—Effect of rotation of the heart upon the direction of the RS-T segment. All curves obtained with normal sinus rhythm.

A, Experiment 2, *a*, after cauterization of the posterior surface of the left ventricle. Elevation of the RS-T segment in all three leads. *b*, after rotation of the heart to the right so as to place the burn anteriorly but still on the left. RS-T still elevated in Lead I, isoelectric in Lead II, and definitely depressed in Lead III.

B, Experiment 12, *a*, after cauterization of anterior surface to interventricular septum. RS-T elevated in Lead I and markedly depressed in the other two leads. *b*, after rotation of the heart far enough to the right so as to place the burn posteriorly and to the right. Depression of RS-T in Lead I and elevation in Lead II and Lead III.

direction of the RS-T segment in this lead took place. Thus, trauma on the left ventricle anteriorly, producing an RS-T elevation in Lead I caused an RS-T depression when the damaged area was rotated to the right side. The results of the rotation experiments are further evidence for the view that the alteration in the direction of the RS-T segment is dependent upon the relationship of the site of injury to the entire ventricular mass and to the recording lead lines and not upon any relationship to anatomical landmarks in the heart itself.

Effect of Prior Cauterization on the Contour of the Extrasystolic Waves.—Comparisons of the curves obtained by stimulation of the six designated areas before and after cauterization revealed that a change in the contour of the second series was present, evidently as a result of the injury. This alteration consisted of either an elevation or a depression of the usually very short isoelectric interval existing between the initial and terminal deflections (Fig. 6). At times the degree of deviation was of sufficient magnitude to obliterate completely or reverse the direction of the terminal and even the initial phase of the extrasystolic wave. It was found, moreover, that for any specific area of cauterization, the direction of this change in the extrasystolic wave was consistently in the same phase in the same lead, no matter where on the heart surface the stimuli were subsequently applied. Further, the direction

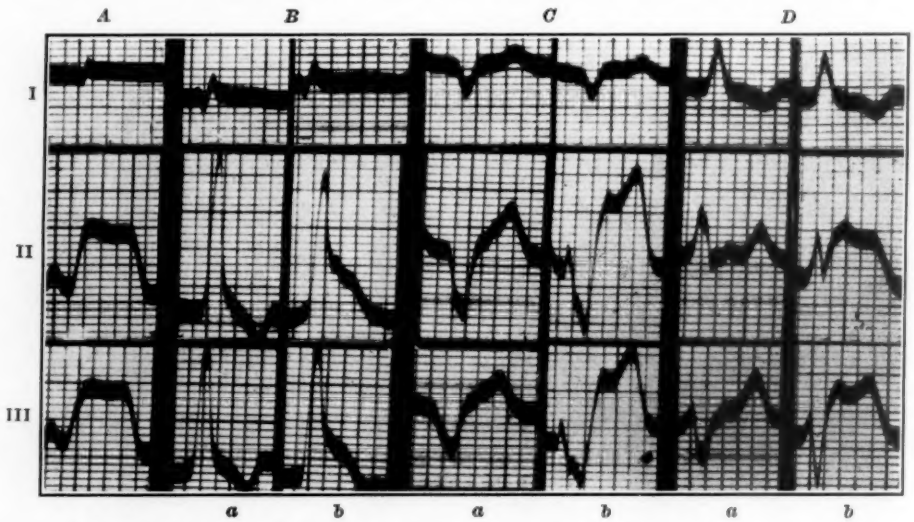

Fig. 6.—Extrasystolic curves subsequent to cauterization.

A, Experiment 9, normal sinus rhythm following cauterization of the left ventricle posteriorly. Very slight elevation in Lead I, marked elevation in other two leads.

B, extrasystolic waves obtained from stimulation of anterior surface of right ventricle: *a*, before cauterization; *b*, after cauterization.

C, extrasystolic waves obtained from stimulation of left ventricle posteriorly: *a*, before cauterization; *b*, after cauterization.

D, extrasystolic waves obtained from stimulation of the right ventricle posteriorly: *a*, before cauterization; *b*, after cauterization. An elevation of the short interval, normally isoelectric, is observed in all the extrasystolic waves of Leads II and III after cauterization. This elevation is similar in direction to the RS-T alteration observed in the control records with sinus rhythm, *A*. Comparable results in Lead I are not discernible.

of the change in the three leads coincided with the RS-T change obtained with normal sinus rhythm. For example, if the left ventricle was cauterized posteriorly, the change in the standard leads consisted of an elevation of the RS-T segment in all three leads (Fig. 6*A*). If now, extrasystoles were elicited although the direction of these initial deflections conformed to those anticipated from the location of the point of stimulation, the change in the isoelectric period was in a positive direc-

tion in all three leads for all sites of stimulation on both ventricles (Fig. 6*B*, *C*, and *D*). The only exception was the occasional absence of change in the extrasystolic waves recorded with Lead I when the original RS-T deviation in this lead was not pronounced.

SUMMARY

In an attempt to explain the characteristic changes observed in the RS-T segment of the standard leads with infarction of specific areas of the heart, six sites on the cat's ventricle were studied. In each experiment one of these was cauterized and the electrocardiographic effects compared with those obtained by previously *stimulating* the same site so as to produce extrasystoles. A comparison was also made between extrasystolic waves elicited from all six regions before and after cauterization of one of them.

1. It was found that the site of cauterization determined the direction of the RS-T interval displacement in the same manner as the site of stimulation determined the direction of the initial deflection of the extrasystolic complex.

2. It was also observed that the RS-T segment was consistently opposite in phase to that of the initial deflection of the extrasystolic wave obtained by stimulation of the site before cauterization.

3. Confirmatory evidence was elicited by changing the position of the trauma by rotating the heart and recording the difference in the displacement of the RS-T segment.

4. It was found that the direction of the deviation of the comparative RS-T interval in the experimental extrasystolic wave elicited after cauterization was determined by the site of the previous injury regardless of the point of stimulation producing the extrasystole.

5. It would appear that in the cat's heart subjected to cauterization: (a) in Lead I the direction of the RS-T deviation depends upon whether the trauma is situated grossly on the right or left ventricle, and

(b) In Leads II and III, the direction of the RS-T deflection depends upon whether the site of injury is on the anterior or the posterior surface of the heart, with the exception that the anterior apical portion of the left ventricle shows the same changes in direction as the posterior surface.

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LIGATION OF THE CORONARY ARTERIES IN JAVANESE MONKEYS*†

III. Further Theoretical Considerations of the Changes in the Ventricular Electrocardiogram, With Illustrative Experiments

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AS THE most prominent and most acute electrocardiographic symptom following coronary ligation in monkeys (Macaca) we described in Parts I and II of this paper,[1] a deviation of the S-T segment which showed in each animal a very definite direction. The direction of the so-called electrical S-T-axis was calculated or constructed by the application of the principles of the equilateral triangle, and it proved to point

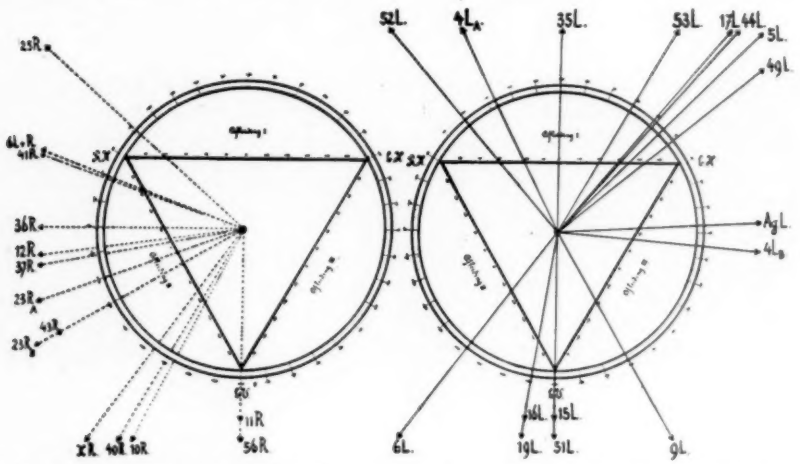

Fig. 1.—Direction of the electrical S-T axis as found in different monkeys after ligation of right coronary artery (R) and anterior descending branch of left coronary artery (L).

preponderatingly in the direction of that part of the heart most affected by the circulation disturbances, as was shown before and is reproduced here in Fig. 1.

In order to get a further insight into the acute results of ligations on the functional conditions of the monkey heart, special investigations were made: in the first place, on the problem whether, as a rule, after coronary ligation acute dynamic changes in the action of the heart *as a whole* were to be found.

In general, such changes were not observed, a finding which agrees with various comparable reports in the literature, for instance those of

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†Preliminary communication on portions of the subject-matter of this paper was made to the 7th Science Congress at Batavia, Java, on October 25, 1935.

Feil and his coworkers,[2] who after ligating the anterior descending branch in dogs found "surprisingly small changes in the mean blood pressure"; and of Orias,[3] who also in dogs sometimes even found the heart action after four minutes dynamically somewhat better than normal and concludes that compensatory mechanisms, especially in the undamaged heart muscle parts, very promptly come into play.

Figure 2 shows one of our experiments in this direction.

In a *Macaca irus* before, during, and after ligation (L) of the anterior descending branch, records were made of respiration and blood pressure, the latter traced from the carotid with an elastic manometer. The changes to be observed in the respiration, systolic and diastolic blood pressure, and pulse amplitude, both in size and frequency, are very slight indeed and even after a considerable time, as also other observations showed us, are usually practically absent, unless, as in Fig. 2, ventricular fibrillation sets in. But even just before this fibrillation, which was preceded by two extrasystoles, there were no definite changes in the functions in question. We are certain that here quite definite S-T deviations had already developed as they were never absent at that stage after left ligation.

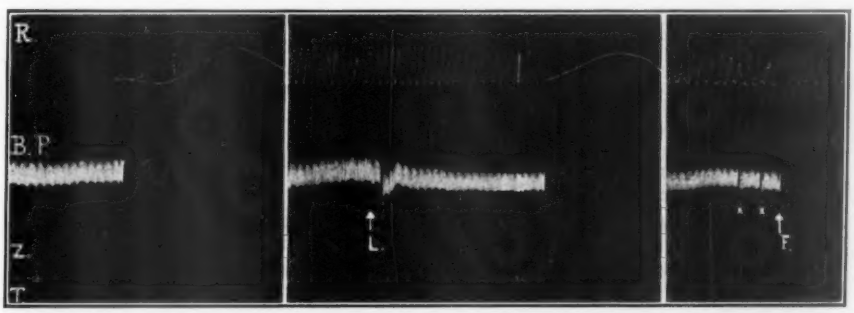

Fig. 2.—Registration of respiration (*R*) and arterial blood pressure (*B.P.*) in a monkey, during ligation of the ramus descendens anterior.

Part 1: Before operation. Part 2: Just before and after ligation (*L*). Part 3: About 10 min. after ligation, extrasystoles (*X*) and fibrillation (*F*). *Z*, zero line of elastic manometer. *T*, time in 5 sec. On the last of Parts 1 and 2 the rate of drum. movement was quickened.

As has been said before, in the great majority of our electrocardiograms the heart rate, which can be considered as a very sensitive indicator for possible postoperative disturbances in the dynamic functions of the heart as a whole, did not show any definite changes in our monkeys after ligation.

Since, as has been mentioned, the changes in the ventricular electrocardiogram, namely the S-T deviations, begin so quickly that it is possible even during the course of the experiment to predict from the change in string movements whether the ligation has or has not been successful, we are of the opinion that these electrical phenomena are independent of any definite hypofunction or hyperfunction of the heart *as a whole*. In this we agree with Orias[3] and with Wood and Wolferth.[4] At any rate, the disturbance in the dynamics of the heart, if it is present at all

in the heart *locally*, is so slight that it is not shown by the methods used in Fig. 2 for investigating blood pressure and respiration.

For the purpose of learning more about the changes in the heart muscle function under the influence of muscular asphyxia, experiments on the whole animal are less suitable, among other reasons because of the vagus effects and the peripheral vascular reactions caused by a general anoxemia.[5]

In our opinion, however, the isolated heart may quite properly be regarded as an example of a many times enlarged heart element. According to Wiggers,[6] the total action of the heart may be considered as being a rapid summation of successive contractions of the individual fractions of the organ, and any change in the total action, if it results from a factor which affects all the parts alike, may be regarded as evidence of similar alterations in the fractionate (ultimate) contraction curves, as long as the ventricles are being excited along the normal pathways.

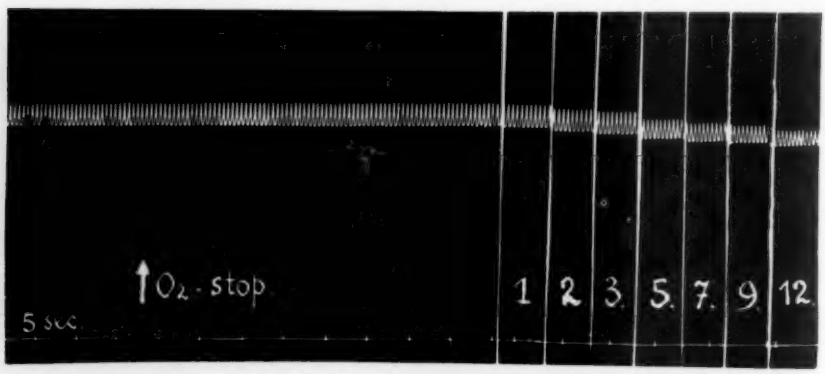

Fig. 3.—Mechanogram of excised Macaca heart perfused with Ringer-Locke (Langendorff method). At ↑ oxygenated saline is replaced by the nonoxygenated solution. Number of next segments shows number of minutes after stoppage of oxygenated saline.

In the literature regarding the relation between oxygen and muscle function, respectively heart function, the monkey heart is not discussed.[7-10] We therefore attempted to get some further information by causing changes in the circulation in monkey hearts isolated and perfused by the method of Langendorff and by observing what changes in the contraction curves accompanied them. These changes may then be considered as reproducing on a large scale, but accurately, the changes that occur in the fractionate contraction curve of each separate heart unit, the oxygen supply of which is disturbed.

In these experiments, which were performed in our laboratory at an average room temperature of 30° C. (86° F.), special care was taken to keep the temperature of the heart as constant as possible.

Two observations are described here as typical of many.

A Macaca heart (see Fig. 3) was perfused according to the method of Langendorff with oxygenated Ringer-Locke solution. When we switched over to nonoxygenated Ringer-Locke solution the ventricular contractions continued for about three minutes practically unchanged. Thereafter the heart action gradually died away. We did not observe a temporary increase in amplitude or any changes in frequency. A slight fall in the base of the curve indicated that there was probably a slight reduction of muscle tonus.

The circulatory changes in the experiment described above are not entirely comparable with those present after coronary ligation, because, although the supply of oxygen was reduced, any accumulation of the waste products of metabolism was combated by the continual perfusion. In order to secure this accumulation of metabolites in addition to the deficiency of oxygen special experiments, one of which will be described (illustrated by Fig. 4), were then made.

In a Macaca heart which was perfused according to the method of Langendorff with oxygenated Ringer-Locke solution, after the amplitudes of the heart contractions had become constant, the entire perfusion was stopped. Directly thereafter, during

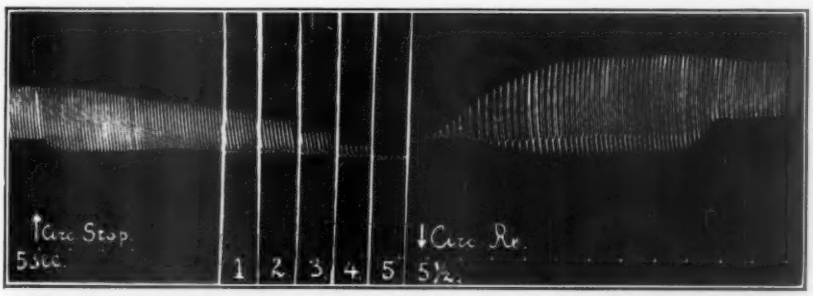

Fig. 4.—Mechanogram of excised Macaca heart, perfused with oxygenated Ringer-Locke solution. At ↑ whole circulation is stopped. Hyperactive phase during ± 12 seconds, followed by progressive decrease in amplitude of movements. Next segments: after 5 min. heart movements nearly stopping; after 5½ min. restoration of circulation (*Circ. Re.*) followed by hyperactive phase of ± 40 sec.

a period of about 12 sec., a phase developed in which the tonus of the left ventricle decreased, but the size of the contractions temporarily increased, only to fall off gradually again. The original amplitude was 18 mm.; the circulation being stopped, it became after 5 sec. 21 mm., after about 12 sec. again 18 mm., after 1 min. 15 mm., after 2 min. 12 mm., after 3 min. 8 mm., after 4 min. 4 mm., after 5 min. 2 mm. After 5½ minutes, the heart movements just having stopped, circulation was restored. The heart recovered, passing again through a hyperactive phase, this time lasting about 40 seconds.

In this last experiment, therefore, in which the accumulation of the metabolites occurred to a higher degree, we observed a temporary mechanical hyperfunction (staircase) during the first period in which they were being piled up, which was followed, however, within 12 seconds by a gradually increasing hypofunction.

It is possible that this temporary hyperfunction, the existence of which has been described in the skeletal muscles of birds in similar circumstances by Van Dyk,[11] might, if the coronary circulation is locally dis-

in the heart *locally*, is so slight that it is not shown by the methods used in Fig. 2 for investigating blood pressure and respiration.

For the purpose of learning more about the changes in the heart muscle function under the influence of muscular asphyxia, experiments on the whole animal are less suitable, among other reasons because of the vagus effects and the peripheral vascular reactions caused by a general anoxemia.[5]

In our opinion, however, the isolated heart may quite properly be regarded as an example of a many times enlarged heart element. According to Wiggers,[6] the total action of the heart may be considered as being a rapid summation of successive contractions of the individual fractions of the organ, and any change in the total action, if it results from a factor which affects all the parts alike, may be regarded as evidence of similar alterations in the fractionate (ultimate) contraction curves, as long as the ventricles are being excited along the normal pathways.

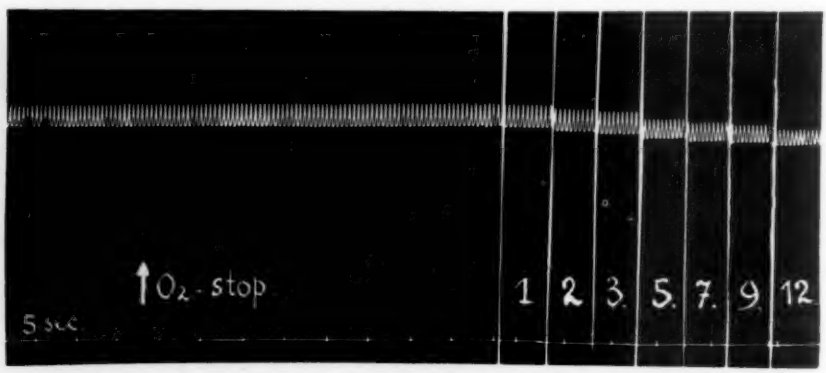

Fig. 3.—Mechanogram of excised Macaca heart perfused with Ringer-Locke (Langendorff method). At ↑ oxygenated saline is replaced by the nonoxygenated solution. Number of next segments shows number of minutes after stoppage of oxygenated saline.

In the literature regarding the relation between oxygen and muscle function, respectively heart function, the monkey heart is not discussed.[7-10] We therefore attempted to get some further information by causing changes in the circulation in monkey hearts isolated and perfused by the method of Langendorff and by observing what changes in the contraction curves accompanied them. These changes may then be considered as reproducing on a large scale, but accurately, the changes that occur in the fractionate contraction curve of each separate heart unit, the oxygen supply of which is disturbed.

In these experiments, which were performed in our laboratory at an average room temperature of 30° C. (86° F.), special care was taken to keep the temperature of the heart as constant as possible.

Two observations are described here as typical of many.

A Macaca heart (see Fig. 3) was perfused according to the method of Langendorff with oxygenated Ringer-Locke solution. When we switched over to nonoxygenated Ringer-Locke solution the ventricular contractions continued for about three minutes practically unchanged. Thereafter the heart action gradually died away. We did not observe a temporary increase in amplitude or any changes in frequency. A slight fall in the base of the curve indicated that there was probably a slight reduction of muscle tonus.

The circulatory changes in the experiment described above are not entirely comparable with those present after coronary ligation, because, although the supply of oxygen was reduced, any accumulation of the waste products of metabolism was combated by the continual perfusion. In order to secure this accumulation of metabolites in addition to the deficiency of oxygen special experiments, one of which will be described (illustrated by Fig. 4), were then made.

In a Macaca heart which was perfused according to the method of Langendorff with oxygenated Ringer-Locke solution, after the amplitudes of the heart contractions had become constant, the entire perfusion was stopped. Directly thereafter, during

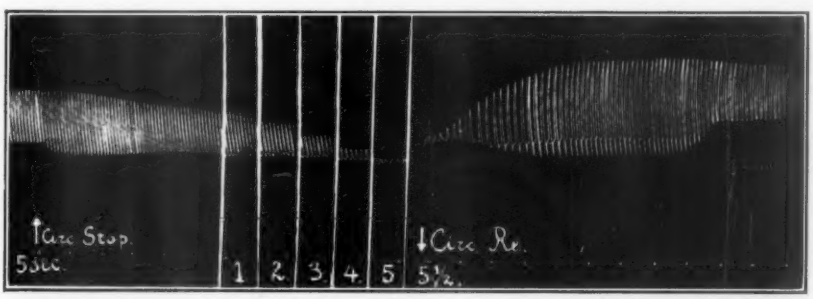

Fig. 4.—Mechanogram of excised Macaca heart, perfused with oxygenated Ringer-Locke solution. At ↑ whole circulation is stopped. Hyperactive phase during ± 12 seconds, followed by progressive decrease in amplitude of movements. Next segments: after 5 min. heart movements nearly stopping; after 5½ min. restoration of circulation (*Circ. Re.*) followed by hyperactive phase of ± 40 sec.

a period of about 12 sec., a phase developed in which the tonus of the left ventricle decreased, but the size of the contractions temporarily increased, only to fall off gradually again. The original amplitude was 18 mm.; the circulation being stopped, it became after 5 sec. 21 mm., after about 12 sec. again 18 mm., after 1 min. 15 mm., after 2 min. 12 mm., after 3 min. 8 mm., after 4 min. 4 mm., after 5 min. 2 mm. After 5½ minutes, the heart movements just having stopped, circulation was restored. The heart recovered, passing again through a hyperactive phase, this time lasting about 40 seconds.

In this last experiment, therefore, in which the accumulation of the metabolites occurred to a higher degree, we observed a temporary mechanical hyperfunction (staircase) during the first period in which they were being piled up, which was followed, however, within 12 seconds by a gradually increasing hypofunction.

It is possible that this temporary hyperfunction, the existence of which has been described in the skeletal muscles of birds in similar circumstances by Van Dyk,[11] might, if the coronary circulation is locally dis-

turbed, sometimes last longer in the heart part involved, but we did not get that impression. It is true that Rothberger[12] mentions that, after tying off very small branches of the anterior descending artery, the heart contractions occasionally became more powerful, but, even so, only for a very short period. We, as well as he and others,[3, 12-16] in examining the portion of the heart concerned after ligation, have usually observed decrease of activity in addition to discoloration.

The principal point is, however, that while accepting these *local* reductions of activity, possibly preceded by a brief *local* increase of function, as facts, we deny that there would be any right because of them to speak of a hyperfunction or hypofunction of the left or right heart *as a whole.* As a rule, as has been said above, the latter could not be observed in the great majority of our cases. Also clinical symptoms of heart failure appeared in only a few of our cases.

A local hyperfunction is, then, either absent entirely or of too short duration to explain the S-T deviation.

It would therefore be possible to consider a local hypofunction in the sense of a decrease of a local action current as the cause of the deviation. An argument against this, however, is the fact that the S-T deviations begin to fade away in an average time of one hour and often finally completely disappear. It is not at all probable that a local hypofunction would so quickly diminish, since the locally disturbed circulation is not restored soon enough, as appears from the formation of an infarct (compare also Orias[3]).

The fact, observed by us and others,[17] that the development of the S-T deviation is usually not accompanied by a change in the still visible part of the QRS complex, nor, according to our measurements, by a prolongation of ventricular systole, makes it hardly probable that the phenomenon could depend on depressed conduction.[18]

Could it be possible that the S-T deviation might be an electrical phenomenon caused by a systolic stretching of the inactive or less active parts of the heart? Such a stretching has been observed after coronary ligation by Lewis[13] in dogs and by us sometimes in monkeys and has also been described recently by Tennant and Wiggers.[19] Stretched tissues may yield deformation currents (de Meyer[20]). Is then the deviation after ligation the result of the interference of the ventricular electrocardiogram with a systolic deformation current?

We believe this to be improbable for the following reasons:

First, such deformation currents are too small (Gilson[21]) to be able to cause the S-T deviations, which are often of considerable size. Second, one may conclude from the curves of de Boer[22] that, at least in the frog heart, if only the base of the ventricle is active, it makes no difference to the electrocardiogram whether the inactive apex is not stretched (in a

bloodless heart) or whether it is being stretched as a heart hernia. Third, it is most improbable that the local stretching, like the S-T deviation, would reach a maximum in about one hour and would then, like the S-T deviation, begin to decrease, since it is generally accepted, at least in man, that the weakness of the ventricular wall is at its height during the second week after the obstruction of a coronary artery.[23]

On the basis of our observations, our study of the literature, and the experiments to be described further below, we prefer the following explanation of the S-T deviation, in which the decrease of this deviation need not parallel restoration of the local disturbances of function.

As a result of the local disturbance of circulation, local damage is done to the muscular tissue of the heart. This local damage which, even if incomplete, may eventually manifest itself in changes visible with the microscope,[24, 25] but which certainly does not do so in the early stages of its existence, discloses itself electrobiologically by a local depolarization of formerly polarized cell membranes, and therefore by increased permeability, decreased contractility, and, at this time most important of all, the local development of a relative electronegativity.[26-30] This local electronegativity produces a current of injury which, as is the case with all injury currents, exists only temporarily.

The S-T deviations which, as we have described, develop quickly, maintain a definite direction during their existence, reach their maximum in about one hour, and finally tend to disappear, result from the presence of this current of injury in a way that is discussed below.

Several articles concerning injury currents in the heart have appeared in the literature,[31-37] but, as far as we know, only few experiments have been made in that direction in connection with circulatory disturbances. Simon[38] found in the skeletal muscles an increased permeability in muscular asphyxia; Embden[39] the same in fatigue; and Wood and Wolferth[4] found that in a dog's heart after arterial ligation the electrogram recorded by direct leads from the damaged part quickly altered even when no changes were yet visible in the indirect leads. Very recently Johnston, Hill, and Wilson[40] showed by direct leads from the dog's heart that within some minutes after ligation the region supplied by the ligated vessel yielded a monophasic curve, from which finding they conclude that the muscle was capable of producing a large current of injury.

Before this last paper was published we investigated whether indeed by disturbances in the circulation an injury potential would develop in the monkey heart, which as with every other injury potential would be especially observable during rest, in the case of the heart then during diastole. The following experiment may be described as typical:

A Macaca heart was perfused according to the method of Langendorff with oxygenated Ringer-Locke solution. A nonpolarizable Porter electrode (*A*) was placed

in contact with a part of the conus arteriosus previously rendered maximally negative by cauterization. A second electrode (*B*) was connected to a healthy part of the left ventricular apex, also by means of a woolen thread soaked with saline (see Fig. 5). Connections with the galvanometer were such that the negative potential of *A* caused the shadow of the string, projected on a scale, to be deflected to the left. In order to neutralize this negativity, compensation was applied according to the method of Poggendorff, so that the compensating current as such moved the string to the right. If now during diastole *B* becomes more negative—in other words, more isoelectric to *A*—the compensating current which in itself is kept constant will become relatively too strong and the position of the string will be shifted to the right during diastole. This is exactly what we observed after the circulation through the heart had been stopped, a procedure we preferred to ligation of an artery, in order to be certain

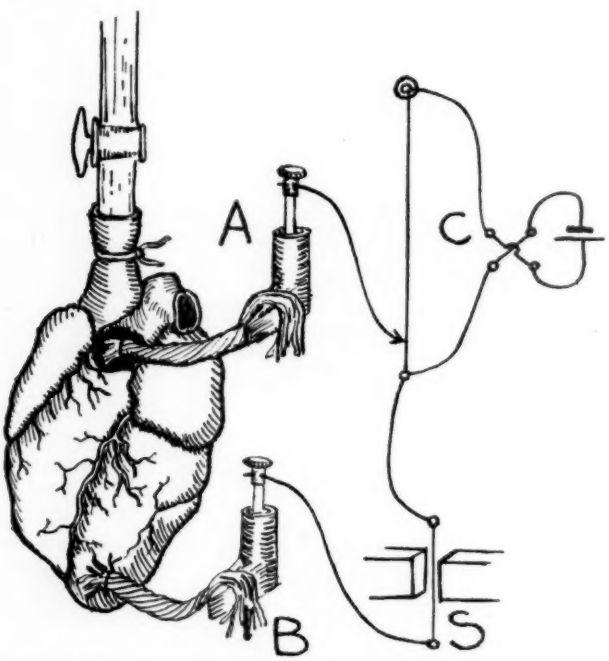

Fig. 5.—Showing arrangement used in experiment described in text. *A*, electrode in contact with burned part of conus arteriosus. *B*, electrode in contact with left apex, becoming temporarily more negative during diastole when circulation in isolated monkey heart is temporarily stopped. *C*, constant compensation; *S*, string.

that the electrode *B* would actually be in a region of disturbed circulation. After restoration of the circulation the diastolic position of the string again shifted in the direction of the original zero. The actual course of events is given here:

11:44 Circulation stopped.
11:46 String during diastole 5 mm. right of zero.
11:53 String during diastole 10 mm. right of zero.
11:56 String during diastole 10 mm. right of zero.
11:57 Circulation restored.
12:01 String during diastole 4 mm. right of zero.
12:03 String during diastole 2 mm. right of zero.

The string tension was such that 1 cm. = 4 mv.

In accordance with this, many curves of Samojloff[32] made by direct leads from the frog heart in comparable cases (damaging the apex by potassium chloride) without compensation show this diastolic displacement of the string quite clearly, for instance his curve *19*, reproduced in our Fig. 6.

Also in the direct leads of Wood and Wolferth[4] the change in the curve, in our opinion, can be explained only as a consequence of an increasing diastolic negativity of the part of the heart involved in the circulatory obstruction, while also the recently published direct leads of Johnston and his coworkers[40] show this diastolic negativity in the dog's heart.

Theoretically it should be possible to observe this diastolic displacement of the string in electrocardiographic records made by indirect leads. Practically, efforts in this direction meet with special difficulties because of the inconstancy of the skin potential.

Our experiment on the isolated monkey heart, described above, showed that the diastolic displacement of the string developed progressively

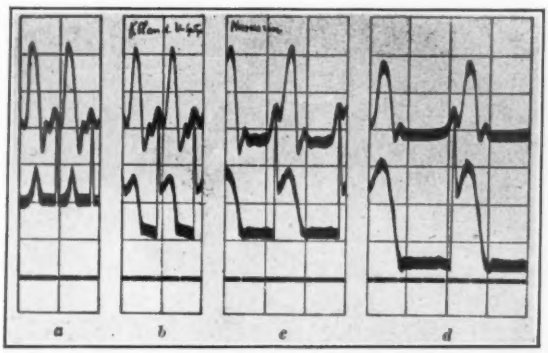

Fig. 6.—First parts of Samojloff's curve *19* described in text. Upper curve, mechanogram. Lower curve, electrogram, direct lead (frog heart). After the apex is damaged with potassium chloride, the string moves downward in diastole. The summit of R and the S-T deviation are in fact the last parts of the electrogram that are not displaced in this curve. No artificial compensation.

within a few minutes after stopping the circulation and tended to disappear again within a few minutes after restoration of it, provided that the circulation had not been stopped too long. This is in agreement with the speed with which the S-T deviation develops after coronary ligation and with which it disappears whenever the obstruction of the coronary circulation is removed after a sufficiently short lapse of time.

Such a reversibility of the deviation has been described in dogs and cats.[4, 41] In the monkey also this reversibility of the S-T deviation appears when the disturbance of the coronary circulation is of but short duration, as shown in the next experiment and in Fig. 7.

Monkey AG.—Leads I, II, and III of the electrocardiogram were recorded simultaneously before the operation (*A*). The opening of the thorax followed. The descending anterior branch of the left artery was closed off by means of a metallic skin clip, and the thorax was closed after the relations of the pericardium and lungs had been restored. The animal thereafter respired spontaneously. After 8 and 10

minutes records were taken (*B* and *C*). These records showed a distinct S-T deviation in all leads. A second operation was then performed. The clip was removed after the artery had been occluded for a total of 14 minutes. The thorax was then closed for the second time and again respiration became spontaneous. Records (*D*, *E*, and *F*) were now made 5, 7, and 11 minutes after restoration of the circulation. The S-T deviation disappeared progressively.

The observations described give an experimental basis for our opinion that the S-T deviations after coronary obstruction are a sign of the development of a local injury potential. This injury potential will mani-

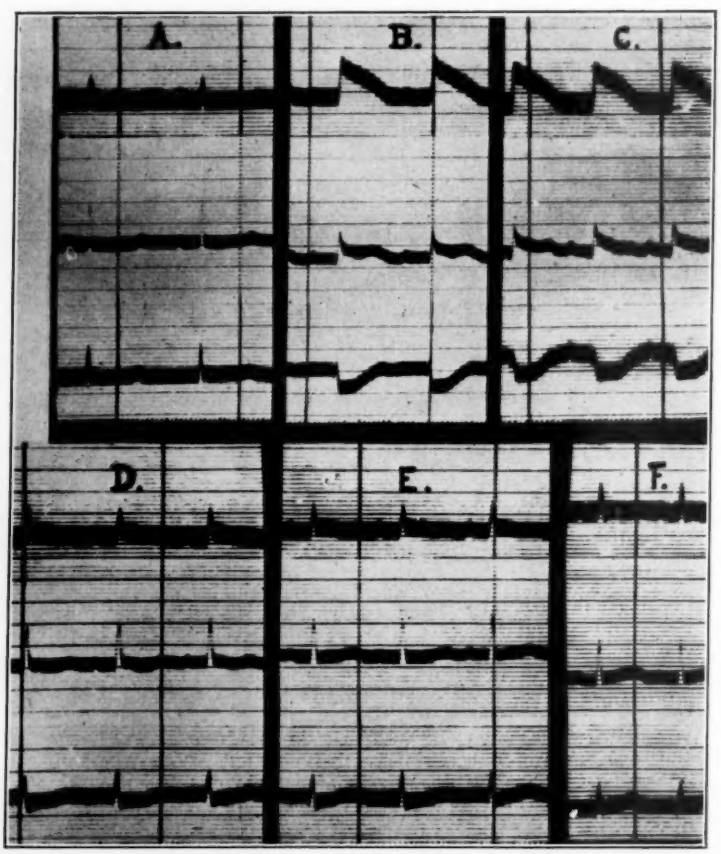

Fig. 7.—Mac. AG (L) Leads I, II, and III simultaneously. *A*, before operation; *B*, 8 min., *C*, 10 min. after the ramus descendens anterior was clamped off. *D*, 5 min., *E*, 7 min., and *F*, 11 min. after clamp was removed. All photograms taken with closed thorax and spontaneous respiration.

fest itself fully during diastole as an injury current. During systole this current of injury will diminish or disappear because at that time the contracting uninjured parts of the heart will also become electronegative.*

*If, during the registration, the diastolic current of injury is artificially compensated, the compensating current during systole will lose its counterbalance. This compensating current will therefore manifest itself especially during systole, which for the deflection of the galvanometer is equivalent to a systolic disappearance of the current of injury.

In this regard the damaged heart will behave as a damaged muscle in general, which also shows its action current as a negative variation of its current of injury and tries to neutralize its current of injury during contraction. The principle is clearly illustrated by an old, but in this respect beautiful, record of Waller [42] which we reproduce in our Fig. 8.

That a current of injury must be considered as a possible factor in the etiology of the early electrocardiographic changes has been stated by others[24, 43, 44, 45] who, however, as far as we know, have made no quantitative directional measurements. Samojloff[46] suggested an area of permanent activity (''permanente Erregungszône'') as a possible cause, which electrobiologically equals a lesion.

The injury current of the heart, manifest especially during diastole, depends upon an injury potential difference *of definite size and direction.* This size and direction will depend upon the intensity and site of the lesion. The S-T deviation is the manifestation of an effort on the part

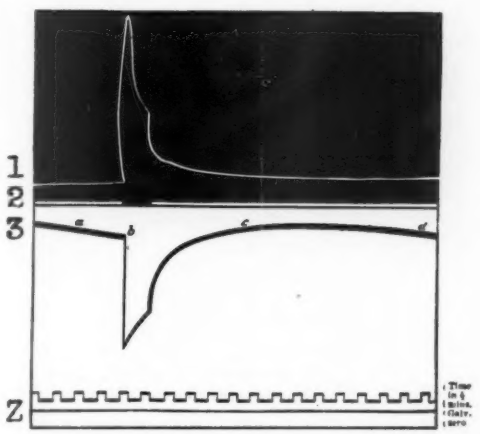

Fig. 8.—Upper curve, tetanic contraction of frog gastrocnemius. Second curve, signal of stimulation. Third curve (black line); accompanying negative variation of current of injury during tetanus. Below, time in ½ min. and zero line of galvanometer (*Z*). The slope from *a* to *d* shows the "natural" decrease of the injury current. (After Waller.)

of the injured heart to reach an isoelectric state during systole, by which effort the string during systole will be moved to, or near to, its true zero position. In the normal heart the same effort to reach the isoelectric state occurs. The deviation as such appears only in the electrocardiogram of the injured heart because only in the latter is *the diastolic position of the string no true zero position.*

The systolic compensation by the heart of its own injury current must occur in the direction diametrically opposite to that in which the original current of injury flowed. The direction of compensation is shown by the direction of the S-T deviation, the construction or calculation of which we described before. *Therefore, the direction of the electrical S-T axis will be the reverse of that of the original injury current.* For that reason it can contribute to our knowledge of the site of the lesion.

Our conception may be illustrated with the assistance of Fig. 9.

On the basis of our observations, the manifest direction in the heart of an injury current caused by a lesion of the left ventricular wall may, in the scheme of the equilateral triangle, be assumed to be from the lesion toward the center of the triangle—for instance from P to Z. The systolic compensation, whether complete or incomplete, will have to be in the diametrically opposite direction, namely, from the center of the triangle to the lesion, from Z to P. As the direction of compensation is represented by the direction of the electrical S-T axis, this latter must point to the lesion, or at least to the electrical center of the lesion.

In Fig. 9, therefore, the deviations $+d_1$, $+d_2$ and $-d_3$, combined according to the triangle scheme, give the direction from Z to P in which the heart tends during systole to neutralize the injury current, pointing in the direction of the lesion and in each lead in the direction of the

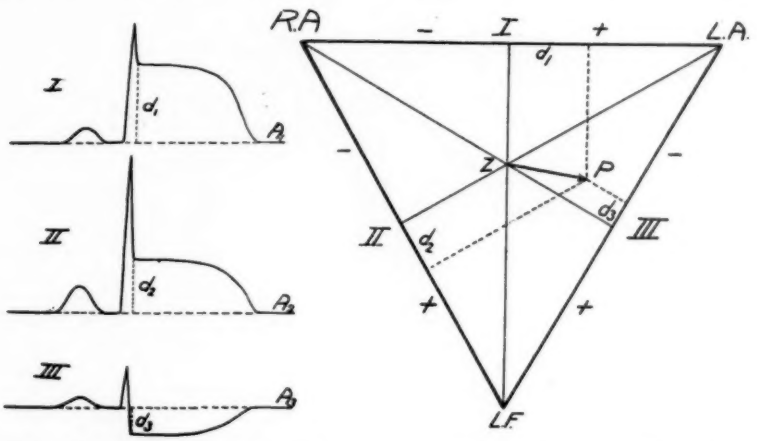

Fig. 9.—Diagram of an electrocardiogram with S-T displacement. The S-T deviations $+d_1$, $+d_2$ and $-d_3$, combined in the equilateral triangle, show the direction ZP, wherein the heart tries to compensate its current of injury, constituting the electrical S-T axis. The injury current passes the heart during diastole from P to Z and is the cause of the diastolic displacements $-A_1$, $-A_2$ and $+A_3$. Further details in text.

true zero position of the string. The diastolic position of the string (A_1, A_2, and A_3) does not represent an isoelectric condition of the heart; in fact, the string is then deviated, in A_1 and A_2 downward, in A_3 upward, by the injury current which at that time is flowing in the heart from P to Z at its full strength.

It must now be explained why we take *for measuring the direction of the S-T deviation that point in the electrocardiogram at which the deviation springs from the QRS complex.*

For taking this point we have the following reasons:

First, this point, at which the curve undergoes an entire change in contour, is usually synchronous in all three leads, so that it may be used even if the records were not made simultaneously.

Second, at this point we are nearest to the instant at which in a normal heart the string returns to the zero line, since by that time the entire ventricular musculature has entered into a state of activity and in the normal heart no further measurable differences in potential exist. It is therefore a logical assumption that in the injured heart at that instant the compensation of the injury current has been established as completely as possible by as complete as possible a ventricular action. At that instant the direction of compensation will then be exposed at its clearest.

Third, as the QRS complex precedes the ejection phase of systole,[33, 34, 47] at the chosen instant no change in form of the heart has as yet taken place; and, on the other hand, there is yet no disactivation of fibers, each of which events might give rise to changes in the S-T axis, for instance, by a displacement of the lesion or by the development of complicating potential differences (for example, interference with a concealed T-wave).

A fourth reason for taking this point is based upon the following line of thought:

In order to explain the normal electrocardiogram, several theories were based on experimental evidence. The most prominent of these theories are those of the "distributed potential differences" and of the "limited potential differences." The first considers the heart as an electrical whole; the second considers the heart muscle fibers as individual electrical units.[33, 35] At this juncture we do not wish to give preference to either of these theories but merely to make the following remarks.

Above in explaining the significance of the S-T deviation after coronary ligation and the meaning of its direction, we paid particular attention to the relationships of the distributed potentials. However, if we choose the above indicated moment in the electrocardiogram for making the measurements, the explanation may be based also on the second theory. For it seems probable that at that moment, *which marks the beginning of the abnormal part of the electrocardiogram*, the action wave, having advanced along the septal conduction system and having penetrated the ventricular walls from within outward, will encounter the damaged fibers at the boundary of the lesion. According to the theory of the limited potential differences, in our opinion, it must be expected that the compensation of the injury current will principally occur by the activation of the uninjured portions of the damaged muscle units, the point of beginning of the deviation in the electrocardiogram then indicating the moment of that activation. In that case too, this compensation, resulting from a negative charge travelling through the ventricular wall from the subendocardial layers outward, must point from the center of the heart to the lesion.

This latter supposition would agree well with the fact observed by others[48] and very distinctly also by us, that in these experimental heart infarcts the subendocardial

*Confirmed by Dr. H. Müller.

layers of the heart muscle are usually spared.* We believe that this must be attributed to the nourishment of those layers directly from the heart cavity, either by diffusion or by the Thebesian vessels. That the action wave in such cases should penetrate the ventricular wall originally undisturbed, till it clashes with the lesion, appears to us entirely logical.

The above mentioned considerations of this subject give, in our opinion, a general understanding of the direction of the S-T axes found in our left and right monkeys.

That these axes, although limited to certain definite fields, do not all coincide in those fields must be expected in connection with various incidental factors, such as:

1. The imperfections in our measurements, partly caused by the difficulty of permanent perfect standardization;
2. The differences in position of the lesions
   a. as a result of individual differences in the course and diameter of the coronary branches,
   b. as a result of individual differences in the speed of development of the lesion on the one hand and of the collateral circulation on the other,
   c. as a result of individual differences in the position of the heart in the thorax, partly increased by differences in respiratory phases;
3. Possibly individual differences in conduction rate in various parts of the heart.

That the *site of the lesions* varied in the different monkeys has already been mentioned in some detail in Part I. To show this in a more compact way we composed the next Fig. 10. In this figure the approximate site of the mass center of the lesion of each monkey heart is indicated, as far as these lesions were found in the ventricular wall with the aid of the microscope.

In seven equidistant parallel planes, perpendicular to the heart axis, the cross-section of each lesion was drawn. The center of such a cross-section was determined and the general center of the whole mural lesion was estimated by taking into consideration the difference in size of the cross-sections found in the separate planes. After these approximate centers were entered into the scheme, each was provided with an arrow indicating the direction of the concomitant S-T axis and with the number of the monkey concerned. In our opinion the position of the center of a lesion during first development will be about the same as that of the center of the lesion shown finally microscopically, since, as described in Part I, the S-T axis of the same monkey, taken at various intervals after operation, shows, as a rule, a tendency to keep a constant direction.

In Fig. 10 is also indicated which of the animals showed septum lesions.

Also from this figure it appears that the S-T axis, especially in those monkeys which showed no septum lesion, points from the center of the heart to the lesion.

We have already described a "mixed field," reaching from +90° to +127°, in which the S-T axes of right and left monkeys overlapped. Among the 5 left monkeys, the axis of which fell in this "mixed field," 3 certainly (6 L, 19 L, and 51 L) and 1 probably (16 L, bundle-branch block) had a lesion of the septum; while of the 9 monkeys in which septum lesions were found (6 left and 3 right monkeys, see Part I) 5 monkeys (3 left and 2 right) showed axes falling in this sector, which after all occupies only about one-tenth of the total field of 360°. We should not be surprised if further studies should confirm the idea that, especially in left monkeys, as S-T axis falling in this sector is a sign of a septum lesion.

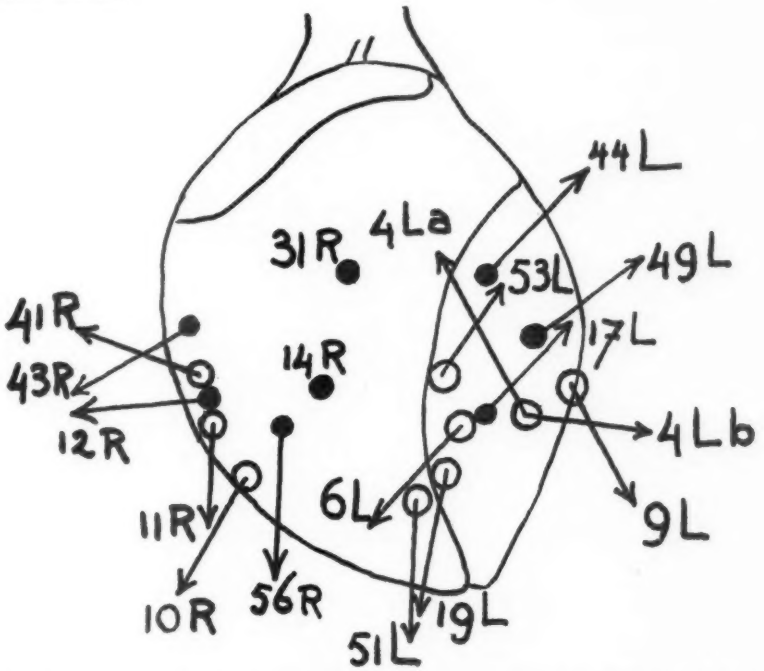

Fig. 10.—An approximate survey of the mass centers of the lesions of the ventricular wall, as far as these lesions finally showed morphologically. The arrows represent the direction of the electrical S-T axis during development of the lesions. Macaca 14 R and 31 R (frontal lesions) showed no S-T displacement. Septum lesions found in monkeys marked ○, no septum lesions in those marked ●. Further details in text.

In this connection the peculiar shifting of the S-T axis observed in Monkey 4 L and described in Part I may perhaps be explained. This animal had a septum lesion and developed an aneurysm in the left ventricular wall. One would be tempted to associate the first phase (4 A : −117°), directed to the base, with the septum and the second phase (4 B : +5°), directed to the left, with the developing aneurysm.

It is, however, also possible that the basally directed tangential components of the action current produced by the ventricular wall, the existence of which components was accepted on theoretical grounds,[49] may be held responsible for the pointing of some of our axes toward the base.

In considering our results, it should be remembered that in Macaca the heart and septum lie in the thorax in a position far more comparable to that in man than in other experimental animals, as for instance in dogs. The electrical axis of the heart of this monkey, measured at the summit of the R-wave, makes an average angle of 63° with the horizontal, but variations between 50° and 75° may easily be found.[50] In several frozen sections we observed that the septum makes as a rule an angle of about 65° with the horizontal, which certainly also may differ in various cases.

We have already mentioned that two of the right monkeys (14 R and 31 R) showed no S-T deviation. We attribute this to the frontal position of the lesions, described before and reproduced in Fig. 10.

As is known, the standard leads give information only about the electrical potential changes as projected on the frontal plane. Potential variations perpendicular to that plane, whether they be the result of action or of injury, are not observable. In Macaca the anterior part of the right ventricle, and especially the part near the conus arteriosus, lies in such a position that it is highly probable that lesions in those regions, such as were present in Monkeys 14 R and 31 R, would manifest themselves either not at all or only in part in these leads. The injury current and its compensation will in those instances be directed practically perpendicularly to the frontal plane.

We believe that the same inefficient condition pertains to the diametrically opposite part of the heart, namely, the posterior wall of the left ventricle near the sulcus longitudinalis posterior.

In this sense the frontal anterior or frontal posterior regions may be considered as "silent areas" of the heart when only the conventional leads are used.

In our experiments no isolated lesions of the posterior heart wall were obtained since in Macaca it is supplied principally by the circumflex branch of the left artery, which was not ligated. We shall make further investigations in this direction. In our opinion, however, it is to be expected on theoretical grounds that lesions, which are mirror images of one another in relation to a frontal plane passing through the hypothetical center of the heart, should give similar electrocardiographic changes because of the similar projection of their electrical components on that plane.

Figure 11 may serve to illustrate this principle of "mirror image lesions."

Some authors are of the opinion that in man lesions of the posterior wall of the left ventricle near the septum could, even if the right ventricle is intact (which is often questionable[51]), produce S-T deviations directed downward in Lead I.[24, 52, 53] Such lesions could, as is mentioned by Barnes and Whitten,[52] sometimes behave as lesions of the right ven-

tricle. This would be entirely in agreement with our point of view whenever a position of the heart may be assumed as reproduced in Fig. 11.

The classical leads therefore will probably be unable to differentiate between such mirror image lesions. On theoretical grounds it may be expected that antero-posterior or precordial leads[4, 37, 54, 55, 56] will be of value in such cases. We have, as yet, no practical experience in this direction.

The gradual *disappearance of the S-T deviation* must, in our opinion, be explained in the following way:

It is well known that injury currents have only a temporary existence and that they decrease and disappear within a rather short time, espe-

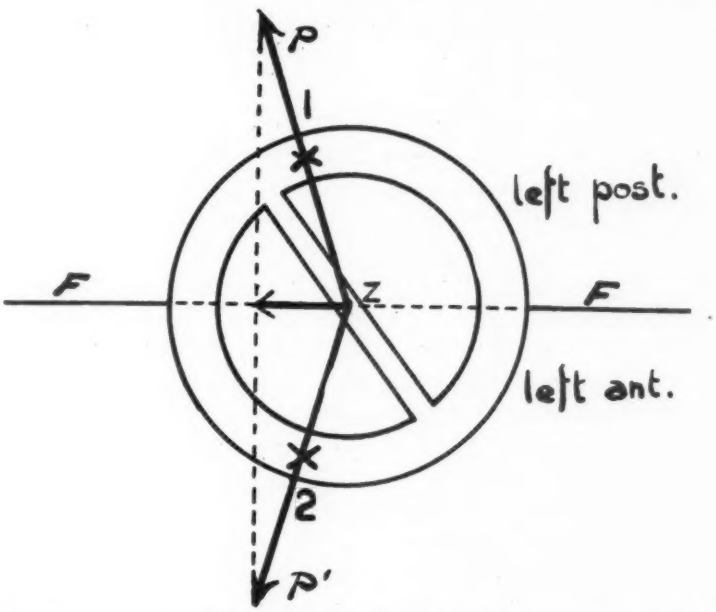

Fig. 11.—Showing the principle of the mirror image lesions described in text. The lesions, *1* and *2*, in posterior part of left ventricle and anterior part of right ventricle may give a similar S-T deviation, this deviation (direction of systolic compensation of current of injury) being determined in the conventional leads by the projection, that *ZP* and *ZP*[1] have in common, on the frontal plane *FF*.

cially in the heart.[26, 32, 33, 34, 57] We have already shown this phenomenon in a skeletal muscle in Fig. 8.

Whenever in the heart the injury potential—in other words, the local relative negative potential—disappears, the S-T deviation will disappear. In the case of disturbances of short duration (Fig. 7) this occurs because the entire process in the cells is still reversible and therefore the tissue elements return to their original condition and function without permanent changes having developed. In disturbances of longer duration that give rise to permanent local anatomical and functional changes, it occurs presumably because the remaining muscle substance is again enclosed by polarized membranes; while the developing connective tissue

cells, which furthermore are not concerned in the transmission of the action wave, must also be considered as being encapsulated by similar membranes. The demarcation after the injury is not the cause of the current of injury but is the cause of the disappearance of the current.[26, 27]

Therefore, it will be just the fresh, electrically active changes in the heart substance that will be able to give rise to definite S-T deviations. When the lesion has once become electrically inactive or less active, a new lesion must be able to impress itself upon the electrocardiogram, as we observed in Monkey 6 L + R and as is perhaps also present in Monkey 4 L (types A and B).

How are the *after-waves,* which develop so frequently during the regression of the S-T deviation, to be explained?

As a rule those after-waves point in a direction opposite to the S-T deviation and are accompanied by a prolongation of the ventricular complex, i.e., the ventricular systole, so far as that is measurable in the electrocardiogram. Evidently, therefore, they are connected with a prolonged action of some part of the heart muscle (compare also[32, 58] and Figure 235 given by Einthoven[33]). Considering that the direction of the after-wave is opposite to that of the S-T deviation, in other words that it is the same as that of the original current of injury, it seems possible that the after-wave must be attributed to a prolonged negativity of muscle elements near the lesion, i.e., a prolonged activity of muscle parts of especially that side of the heart where the lesion developed.*

It is known of both heart and skeletal muscle that under mechanical overloading or after various functional injuries, such as in aortic stenosis,[59] enlarged venous inflow,[60] and fatigue,[61] the contraction is prolonged, particularly in the phase of relaxation. It is possible that a comparable prolongation of contraction occurs in the hearts in question since a resistance in the circulatory system, in itself normal, may mean an increased resistance to an injured heart. The remaining muscle mass of the damaged ventricle may possibly need more time to bring the original systolic blood volume to the original pressure, and to eject it, than was needed formerly by the undamaged ventricle. A prolongation of systole may also point to increased initial tension and diastolic size.[3] It is also quite conceivable that in some cases processes of compensatory hypertrophy, which we have often believed present in the remaining parts of the damaged ventricle, play a rôle and lead to a prolongation of conduction and activation.[62]

Whatever the truth may be, in our opinion the after-wave is to be regarded as the expression of a heart action altered in consequence of the loss of former muscular elements. Further insight into the exact meaning of this wave will be obtainable only when through the applica-

*The theory of the limited potential differences leads to interpreting the after-wave as a late retreat of the excitation wave in fibers which produce during activation a deflection in the opposite direction of the after-wave, i.e., in the direction of the S-T deviation. This would then also mean a late disactivation of fibers in the neighborhood of the lesion.

tion of adequate physiological methods a further investigation is made of the functional changes of various parts of the heart, not only in the acute phase, but also during the period of cicatrization.*

We found that the after-wave as a rule was not accompanied by an increased duration of the QRS complex and, even if septum lesions were absent, not by a definite change in this complex. In our opinion this indicates that the components of the electrocardiogram, however one may consider them, are not shifted in their initial phases, so that probably some, beginning at their original time, are prolonged with or without a change in their detailed configuration.

The following *final remarks* may serve to prevent any misunderstanding.

Solely for the sake of brevity we have used here and there the term "coronary electrocardiogram." We wish to point out that, although on the basis of our experiments and observations we regard the cause of the S-T deviations discussed before to be a lesion manifesting itself electrically and although it seems to us to be permitted to extend this conclusion to comparable cases in human pathology, we do not mean to say that each and every displacement of the S-T segment in any given electrocardiogram must necessarily point to a disturbance in the coronary flow or to a locally developed injury potential.

The explanation of the fact that the S-T segment usually belongs to the equipotential parts of the normal electrocardiogram is not known with absolute certainty. In the literature[33] two possibilities are suggested:

1. All the heart muscle elements are in complete contraction so that there is no potential difference in any of them and thus no action current flows through the galvanometer.
2. There are indeed potential differences present in the heart muscle, but they happen to balance out, so that the manifest resultant of all potential differences in the customary leads happens to be zero.

Now it is a common experience that sometimes in man small deviations of the S-T segment from the diastolic line may be observed without there being any reason to suspect the presence of a pathological heart or of an injury current.† In several of Einthoven's classical "normal" curves they are also to be found. Is there in such an instance no period of collective contraction of the muscle elements, or do potential differences of such direction and size develop that a measurable resultant remains? Or have certain potential differences either not developed at all, or to a smaller degree, or in other time relationships? Can this occur to a cer-

*The recent work of Wilson, Hill, and Johnston,[63] made by direct leads in the dog's heart, considers the disappearance of the electrical forces formerly produced by the muscle part deprived of its blood supply as concerned in the later changes of the electrocardiogram.

†We do not deny the possibility of the existence of such small physiological variations in monkeys, but we have not seen them with certainty and, in our opinion, they play no part in the observations we have described.

tain extent in a healthy heart? Is it in this direction that an explanation must be sought for S-T displacements when the contractions of left and right ventricle are shifted in time, as in extrasystoles and conduction disturbances,[64] S-T deviations such as described in heart strain,[65] and under the influence of digitalis[66]? In both of these last groups of cases, however, lesions are also often found.[25, 67] Are displacements of the S-T segment as seen in rheumatic fever,[68, 69] pericardial effusion,[70, 71] anoxemia,[72-75] yellow fever[76] based on the influence of an injury current as are those after coronary obstruction?

In all such cases it will, in our opinion, be useful to determine the direction of the S-T axes and to look for a correlation with definite disturbances in the heart muscle and heart function.

It is not our intention to enter further into these still outstanding problems at this time.

SUMMARY

A further study was made of the acute results of coronary ligation on the functional conditions of the heart in the Javanese monkey *(Macaca irus)*. In general, no acute dynamic changes in the action of the heart *as a whole* could be found after ligation. Therefore such changes cannot be the cause of the S-T deviations observed in such cases. Experiments on the isolated monkey heart lead one to accept the view that probably a *local* hypofunction, perhaps preceded by a short *local* hyperfunction, occurs in the portion of the heart deprived of its blood supply. The time relationships, however, show that they cannot be the cause of the S-T deviations observed. A depressed conduction or a deformation current is also excluded as a possible cause of the S-T deviation after ligation. The S-T deviation after ligation is explained to be, in its time relationships and its direction, the result of the development, temporary existence, and successive disappearance of a current of injury. The direction of the current of injury in the heart depends upon the site of the lesion. The direction of the S-T axis is the reverse of that of the original injury current and results from systolic compensation of this injury current. The string is deflected or influenced by the injury current especially during diastole. The development of a local electronegativity during diastole was observed in experiments on isolated monkey hearts, the coronary perfusion of which was interrupted. This local electronegativity proved to develop quickly and to be reversible in the isolated heart in case of circulatory disturbance of short duration. The same quick development and reversibility proved to be present in the S-T deviation of a monkey during and after occluding the anterior descending branch for a short time. Reasons are given why, for determining the direction of the S-T axis from the electrocardiogram, that point is taken at which the deviaton springs from the QRS complex. The relation of the site of the lesions to the direction of the S-T axis is described. Septum lesions probably tend to cause an S-T axis in the

"mixed" sector. Frontal lesions may occur without S-T deviations in the conventional leads. The principle of the "mirror image lesions" is described, being lesions in opposite parts of the heart which, by similar projection of their electrical components on a frontal plane, give similar electrocardiographic changes and therefore cannot be differentiated in the standard leads. Disappearance of the S-T deviation is attributed to disappearance of the current of injury, which fact may or may not mean restoration of function. Especially the fresh, electrically active lesions will be able to produce S-T deviations. The after-wave is probably the result of a prolonged action of fibers in the neighborhood of the lesion. Not every displacement of the S-T segment in any given electrocardiogram must necessarily indicate a disturbance of the coronary flow or a local development of an injury potential.

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PULMONARY INSUFFICIENCY WITH A SUPERNUMERARY CUSP IN THE PULMONARY VALVE

Report of a Case with Review of the Literature*

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A CASE is reported here of a patient who during life suffered from pulmonary insufficiency and whose heart at necropsy presented four pulmonary cusps and commissures. Four pulmonary cusps as an accidental post-mortem finding occurs once in a thousand necropsies but, combined with clinical insufficiency of the valve, only three definite cases have previously been reported. Nevertheless, investigation of the literature indicates that the clinical diagnosis of the valvular anomaly might be made more frequently, and it is for this reason that the case and a survey of the literature are presented.

REVIEW OF LITERATURE

Reports of 151 cases of hearts with four pulmonary cusps were found in the literature. Further, through the courtesy of Dr. Maude E. Abbott, it is possible to include three additional cases from the Medical Museum of McGill University,[1] making a total of 154 cases.

Most of the reports of these 154 cases were purely anatomical, giving no information as to the patients' clinical statuses. However, in 24 cases mention was made of the presence or absence of physical signs of pulmonary insufficiency during life. Of these 24 cases, in 3 there was clear clinical evidence, in one possible evidence, and in 20 no definite evidence of pulmonary regurgitation. All 3 cases in which there was clear evidence of pulmonary incompetence during life, likewise included evidence at necropsy. In the one case in which there was possible evidence of clinical insufficiency, no mention was made of anatomical insufficiency. Of the 20 cases in which no signs or symptoms were observed, in 17 there was no evidence of valvular incompetency noted at necropsy, and in 3 cases a dilated pulmonary artery was found.

In addition to these cases, there were seven reports which failed to mention the physical findings during life, but in which evidence of pulmonary insufficiency was discovered at necropsy.

Begbie,[4] Bernabei[5] and Kolisko[39] reported the three cases in which definite evidence of pulmonary incompetence was observed during life.

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In Begbie's case,[4] a boy eighteen years old first consulted the physician because of shortness of breath aggravated by exertion. From earliest recollection he had been unable to run with other boys. There were present on examination a basal systolic thrill and a loud blowing systolic murmur along the left sternal border at the level of the third rib, followed by a diastolic murmur of lesser intensity. The systolic murmur radiated to the entire upper chest, whereas the diastolic was limited to the site of maximum intensity. At the age of twenty-one years the boy died of a fractured skull. The heart anomaly was discovered at post-mortem examination by Haldane.[30] There were three pulmonary cusps of ordinary size and a fourth which was smaller than the others and imperfectly separated from one of them. The water test showed slight incompetence of the valve. The other valves were normal, the heart was normal in size, and the right ventricle was not dilated.

In Bernabei's case[5] a man of fifty-four years died of "collapse" of the heart during a resolving pleuropneumonia. He had suffered from attacks of nocturnal asthma and palpitation for some time before his terminal illness. A soft, weak thrill was felt during systole and diastole. Over the area of the thrill was heard a harsh double murmur. The systolic murmur was the louder, being loudest at the apex. The diastolic murmur was softer and was loudest in the fourth intercostal space to the left of the sternum. The second pulmonic sound was clear and sharp. The second aortic sound was lower pitched and was followed by a faint short systolic blow. At necropsy the pulmonary artery appeared aneurysmal and measured 16 cm. in circumference at a distance of 3 cm. from its origin. There were four pulmonary cusps, of which three were of equal and normal size, and a fourth cusp which was of the same height and thickness but narrower.

In Kolisko's case[39] a woman of thirty-four years thought she was pregnant because of swelling of the abdomen, but actually she suffered from circulatory insufficiency, with ascites, which caused her death. She had suffered for many years from palpitation of the heart, and from time to time from pain in the chest and difficulty in breathing. She came into the hospital complaining of shortness of breath. Physical examination disclosed the evidences of circulatory failure; distention of the neck veins, cyanosis, dyspnea, ascites, and edema of the lower extremities. Systolic and diastolic murmurs were present. On admission, the systolic murmur was heard equally well over the apex and the base of the heart. The diastolic murmur was heard best at the left upper border of cardiac dullness. A week after admission both murmurs were heard only over the pulmonary area. A slightly patent foramen ovale was found at autopsy. There were four pulmonary cusps, of which three were normal in size, and the fourth about half as wide. The right auricle, right ventricle, conus arteriosus, and pulmonary artery were dilated.

Hodenpyl[31] reported the case in which possible evidence of pulmonary incompetence was observed during life. In this case a well-marked presystolic murmur was heard during life, but the location of the murmur was not given nor the anatomical findings other than the supernumerary pulmonary cusp.

In the cases of Cattell,[14] Klob,[38] and Thompson,[68] the hearts presented at necropsy dilated pulmonary arteries, but during life the murmur of pulmonary insufficiency was not heard.

The seven case reports in which evidence of pulmonary insufficiency was noted only at necropsy include the following. In Boettcher's sixth case,[8] necropsy revealed obvious insufficiency of the pulmonary valve. In Brüninghausen's second case,[10] a man aged sixty-four years suffered for years from shortness of breath. No examination of the chest was made before death. But at necropsy the right ventricle was found enormously dilated and the wall greatly thickened. In one of Dilg's two cases,[22] a year-old boy, who died of atelectasis of the lungs and intestinal catarrh, presented at necropsy a dilatation of the pulmonary artery and right ventricle. In Lindenberg's first case,[44] at post-mortem examination a wide pulmonary artery was seen. In Virchow's case[72] the right side of the heart (in a man of fifty-six years) was found greatly hypertrophied, and the pulmonary conus and artery were dilated. The pulmonary valve was incompetent. No clinical account accompanied this report. In one of Viti's two cases[73] a woman died in the sixth month of pregnancy following cardiopulmonary complications. Dilatation of the pulmonary artery and right ventricle and buttonhole mitral stenosis were found. One could not be certain of the cause of the arterial dilatation, whether it was secondary to the mitral stenosis or to the valvular anomaly. In Wauchope's second case[76] necropsy revealed a dilated pulmonary artery.

Frequency.—Dagnini[18] found 5 cases of four pulmonary cusps in 5,000 necropsies at the Institute of Pathological Anatomy of Bologna from 1925 to 1929, inclusive. De Vries[21] found 9 cases in 3,600 in Amsterdam. Houck[32] encountered 2 cases in 5,000 at the Massachusetts General Hospital. Simonds[63] found one case in 20,000 coroner's examinations in Chicago. Simpson[64] found 4 cases in 4,252 necropsies at the West Riding Asylum, Wakefield, England. Thilo[67] found 3 cases in 5,814 at Leipzig. In 23,416 necropsies, 24 cases of four pulmonary cusps were discovered.

Sex and Age.—Of these cases in which the sex was mentioned, 44 were in males and 25 in females. The age of the patients at death varied from five months to eighty years, the average being forty years. In no instance could one definitely attribute the death of the patient to the presence of the anomaly.

Size and Site.—Supernumerary pulmonary cusps may be classified according to size. There are cases in which one cusp is smaller and the other three larger and equal, cases in which one is larger and the other three smaller and equal, cases in which all the cusps are the same size, in which two cusps are smaller and two larger, and in which no two cusps are of the same size. Most of the cases, however, resemble the one here reported in that there are three larger cusps and one small one.

In many instances the supernumerary cusp is deformed, imperfect, or shrunken. Often it is fenestrated.

The site of the supernumerary cusp varies in that it may lie between the left and anterior, anterior and right, or left and right cusps.

REPORT OF CASE

F. E., a widow, forty-one years old, came to the out-patient department of Beth Israel Hospital in 1925 complaining of headache, shortness of breath, and palpitation on moderate exertion, of three years' duration. There was no history of rheumatism or syphilis.

Physical examination revealed a well-nourished woman who appeared comfortable. Her blood pressure was 205/140, the pulse rate 96, with occasional extrasystoles. The second aortic sound was accentuated. There was a soft systolic apical murmur.

In July, 1926, there was heard for the first time a *diastolic murmur* over the *pulmonic area.*

In February, 1928, she complained of shortness of breath, palpitation, and cough on slight exertion. A split first sound was heard at the apex.

In April, 1928, a faint diastolic blowing murmur and a rough systolic murmur were heard over the pulmonary area. The liver edge was palpable two fingerbreaths below the costal margin. The blood pressure was 224/110.

In November, 1928, ophthalmoscopy revealed retinal hemorrhages. At this time fluoroscopic findings (Dr. Nemet) were: triangular heart, moderate enlargement of the left ventricle, marked prominence of the pulmonary artery and conus, obliteration of almost the entire retrocardiac space, widening of the aorta.

The patient was admitted to the hospital for the first time on Sept. 24, 1929, complaining of persistent occipital headache, swelling of the ankles, palpitation, poor vision, and shortness of breath on exertion. For two months previous to admission she had been dyspneic on the slightest exertion, developing pounding of the heart and tingling and pain in the extremities. Further, with the dyspnea, she began to cough and to raise blood-tinged sputum.

There were scattered sibilant râles over both lung fields. The apex beat was palpable in the fifth left interspace; the heart rate was regular. There were present a blowing, soft, apical systolic murmur, a low-pitched basal systolic murmur, and a faint, high-pitched basal diastolic murmur. The blood pressure was 260/150.

Kidney function was good. The blood Wassermann test was negative. The roentgenogram of the chest (Fig. 1) showed congestion of both lungs, accentuation of the pulmonary conus, generalized enlargement of the cardiac shadow, and a heart shape characteristic of mitral valvular disease. Ophthalmoscopic examination showed retinal edema and hemorrhage.

The patient was discharged on Nov. 12, 1929, as improved.

Second Admission.—She was readmitted Jan. 6, 1930, having remained at home in bed from the time of discharge, two months before. Four days prior to admission the patient suffered a sudden severe headache which lasted for two days.

She had also precordial pain and palpitation and was dyspneic. The day before admission she awoke from sleep dazed, recognized no one, recalled nothing, but suffered no paralysis. The fingers of both hands developed a pins-and-needles sensation, and her entire left arm felt weak.

The blood pressure was 230/140. The heart rhythm was normal, and the heart was much enlarged. There was a rough systolic murmur at the base of the heart, heard best over the sternum; a faint diastolic murmur, heard best in the pulmonary area; and a faint systolic apical murmur. A few crepitant râles were heard over both lung bases. The liver edge was two fingerbreaths below the costal margin, and tender. There was no edema of the legs.

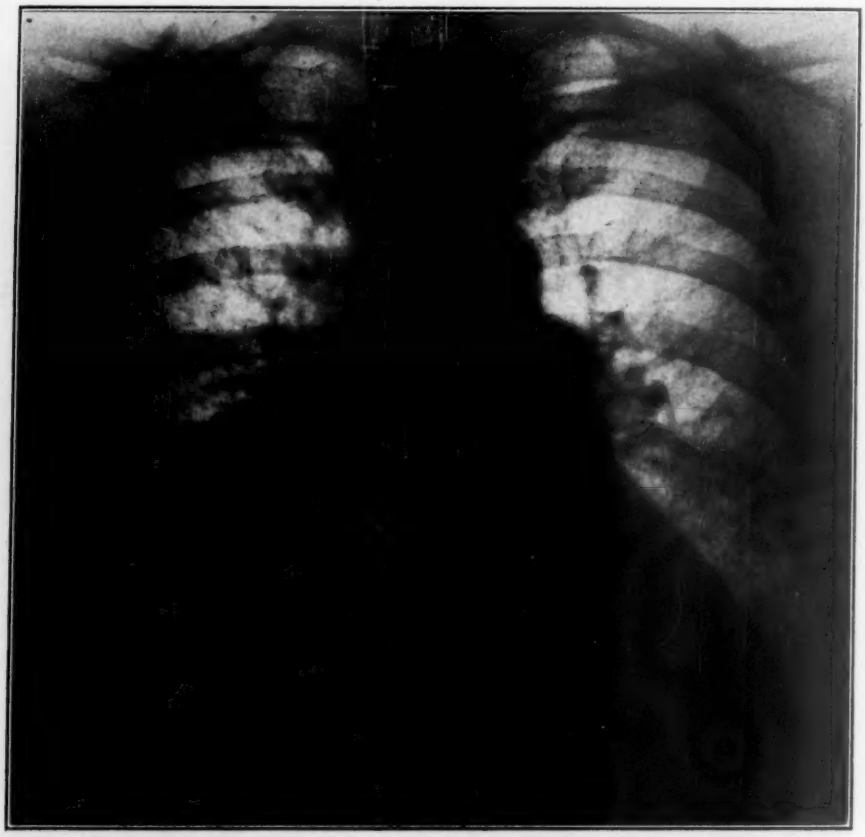

Fig. 1.—Roentgenogram taken September, 1929. Note the generalized enlargement of the cardiac shadow, and particularly of the pulmonary conus.

Roentgenograms of the chest showed the heart shape characteristic of mitral valvular disease. The electrocardiogram showed bundle-branch block. Kidney function was normal.

The patient was discharged April 14, 1930, in an improved condition.

During the summer, while under observation in the out-patient department, she developed auricular fibrillation. This, however, caused no change in her condition, as she was well digitalized.

Third Admission.—She returned to the hospital for the third time on Oct. 11, 1930. She had been fairly comfortable until three days prior to admission when

she began to suffer from vague generalized pains, most severe in the upper abdomen. She became nauseated and vomited several times. This was followed by dyspnea and edema of the ankles. Two days prior to admission she coughed up blood-tinged mucus.

She presented on admission the classical signs of circulatory insufficiency, dyspnea, orthopnea, cyanosis, congestive râles at both lung bases, and fluid in the left pleural cavity. The liver edge was two fingerbreaths below the umbilicus. The spleen was not palpable. There were ascites and moderate edema of the lower extremities. The heart rate was 96, the pulse rate 84, with auricular fibrillation. The blood pressure

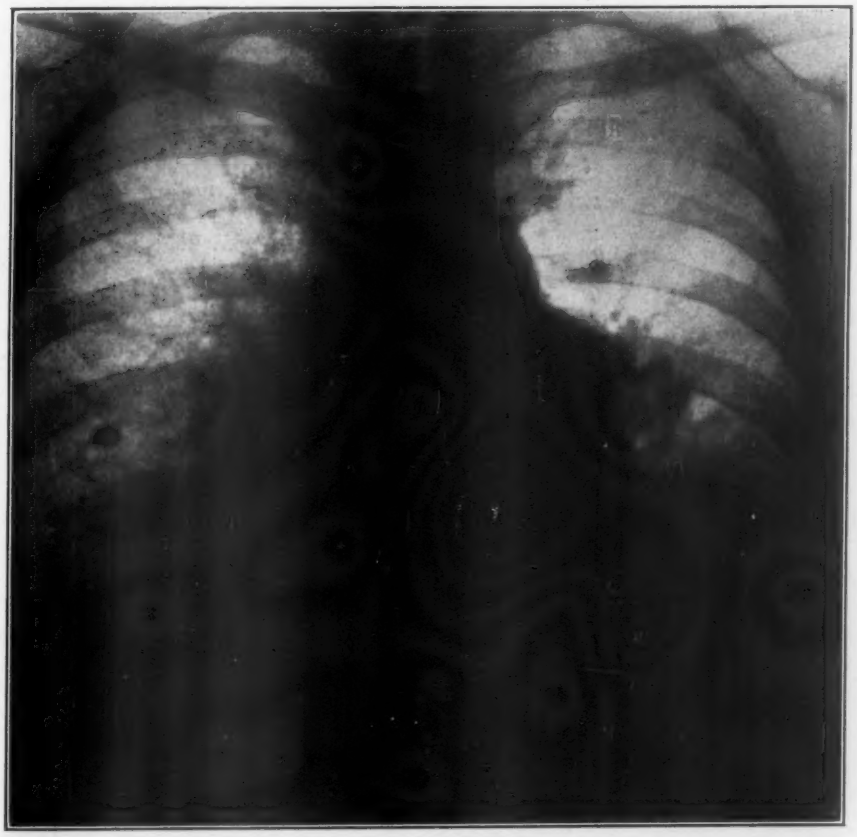

Fig. 2.—Roentgenogram taken October, 1930. Note the increase in the size of the pulmonary conus.

was (about) 240/130. The apex beat was heaving and was palpable in the sixth left interspace, 11 cm. from the midline. A diastolic shock was palpable over the base of the heart. The first sound was short. The second aortic sound was accentuated; so, too, was the second pulmonic sound, being even louder than the aortic.

At the apex of the heart a short diastolic sound or murmur was heard. It was rather faint, low pitched, and not transmitted. There was a short blowing apical systolic murmur. *At the base of the heart, heard best over the sternum and transmitted equally to the left and right of the sternum, in the second and third interspaces, was a very loud, high-pitched, blowing diastolic murmur. There was also a rough systolic basal murmur.*

A roentgenogram of the chest (Fig. 2) revealed a mitral heart configuration, with marked enlargement of the pulmonary conus. The blood pressure readings were as follows: left upper extremity, 200/124; left lower, 202/134; right upper, 176/118; right; right lower, 192/134.

The patient did not improve with digitalis and the theobromine preparations. She complained constantly of pain over the liver. She died suddenly on Dec. 3, 1930.

The diagnosis considered most likely was mitral stenosis with aortic insufficiency. The basal diastolic murmur was louder and more constant and had a wider propagation than the usual Graham Steell murmur. This suggested the origin of the murmur in the aortic valve rather than in the pulmonic. Furthermore, the patient's pulse pressure was so high (60 to 110 mm.) that a Corrigan pulse was present. In retrospect we realize that we should have been impressed by the enlargement of the pulmonary conus and the negative Hill's sign.[81]

Post-Mortem Findings

The post-mortem examination was made by Dr. Alfred Plaut, to whom I am indebted for the pathological report. The body was that of a middle-aged white woman of medium height who was fairly well nourished. The heart findings only are given in detail.

The heart weighed 575 gm. and measured 11 by 10 by 6 cm. The apex was formed by the left ventricle. The left edge of the heart was very much rounded. The right ventricle was not as hard as the left but still was fairly well contracted. The mitral and tricuspid ostia were normal in width. The left ventricle was wide, but not in relation to the thickness of its wall. The anterior wall reached a thickness of about 3 cm. The papillary muscles were thick and slightly flattened. The trabeculae were more flattened than the papillary muscles. The upper half of the anterior portion of the septum was thinned out in a circular area nearly 4 cm. in diameter. The inner posterior margin of this area came fairly close to the location of the bundle of His. This margin was vertically below the commissure between the right and posterior aortic cusp. The lower margin of the area of myomalacia was situated at the origin of the posterior capillary muscle, while its uppermost end nearly touched the septum membranaceum. The area surrounding the coronary vein on the right side of the septum atriorum was intact as was the lower edge of the septum membranaceum. The tissue of the septum outside the area of myomalacia appeared intact. In this circular area, which lay a few millimeters below the level of the surrounding endocardium, the color gradually changed from reddish brown to purplish yellow. The wall in the center of this area was thinned out to about 4 mm. Directly under the endocardium there were yellow streaks which corresponded to the yellow areas seen from the inside. The mitral and aortic valves appeared normal except for small thickenings. The commissures were not widened. The aortic ostium, after opening, measured 6 cm. The tricuspid valve was intact. The pulmonary ostium, after opening, was a little over 7 cm. wide. The pulmonary valve, notably the anterior cusp, stretched considerably when the ostium was opened. The pulmonary artery was very inelastic, notably in comparison with the rather elastic aorta. A few small yellow spots were visible in the intima over the attachment of the ligamentum arteriosum. Otherwise the pulmonary artery appeared intact.

There was an extra commissure between the right and the anterior cusp, making an abortive supernumerary cusp, 4 mm. wide (Figs. 3 and 4). The commissures were nearly equal in length and created a fold on the inside of the pulmonary valve when the valve was pulled downward. They differed in thickness, the left one being considerably thicker than the right. Only the right commissure united

the upper edge of the valve with the pulmonary artery and with the edge of the neighboring cusp. The thicker commissure united the anterior cusp to the pulmonary artery and was attached nearly 2 mm. below the free margin of the valve.

The right ventricle was considerably narrowed by the bulging of the hypertrophic septum. The papillary muscles were slightly thickened. The trabeculae appeared more hypertrophic, notably over the septum. They were not flattened to any marked degree. The anterior wall without trabeculae had an average thickness of 3 mm. The myocardium was very firm throughout with the exception of the above mentioned area of myomalacia. It was very shiny, pale pink, homogeneous, with very indistinct markings on the cut surface. The upper half of the left posterior papillary muscle contained gray and yellowish spots. Long section through the left anterior papillary muscle revealed extensive scar formation. The subepicardial fat, which was fairly thick, was well separated from the myocardium. The ascending aorta as elastic and thin, and there was much atheroma but no sclerosis. The left coronary artery was normal in width but was atheromatous. The wall was not hardened and the lumen not narrowed. Behind the left edge,

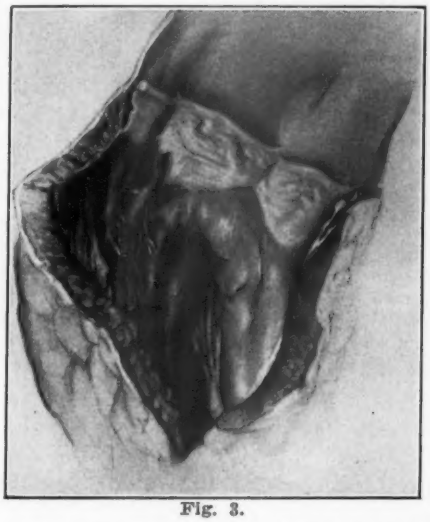

Fig. 3.

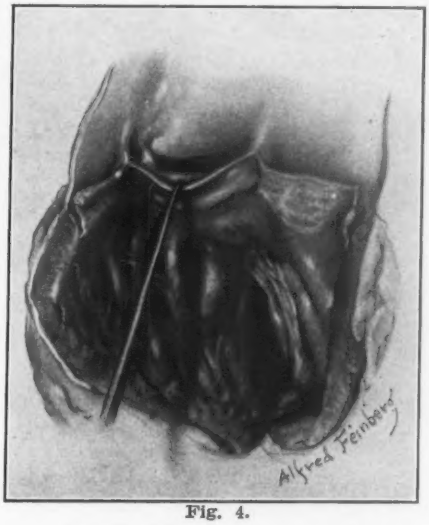

Fig. 4.

Fig. 3.—A dimple is visible at the site of attachment of the supernumerary commissure. The supernumerary cusp is left of this commissure. This illustrates the ease with which the anomaly may be overlooked.

Fig. 4.—The abortive supernumerary cusp lies between the anterior cusp, which has been pulled down, and the right cusp.

however, thick, firm, yellow masses narrowed the lumen and occluded it completely 5 cm. from the aorta for a distance of about 0.5 cm. Below the occlusion the lumen was fairly normal and the wall of the artery thin. The ramus descendens anterior was considerably atheromatous down to the middle of the left ventricle, where the wall became normal. The right coronary artery was normal in width nearly up to the right edge, although many yellow deposits were found in the intima. Directly behind the right edge, the lumen was occluded for a distance of 5 cm. by an adherent red thrombus. The thrombus was situated in a moderately narrowed vessel with considerable atheromatosis. Beyond the thrombosis the lumen was slightly narrower than the normal. There was considerable atheromatosis of the horizontal branch, while a branch going down toward the apex appeared fairly normal except for its beginning. The myomalacious spot was situated directly below the point of occlusion.

The aortic arch was moderately arteriosclerotic. The thoracic aorta was elastic, with considerable atheromatosis. Its average width was 5 cm.

Microscopic Examination.—In the thin portions of the pulmonary valve, including the normal commissure, only minor changes could be detected. There were, for instance, small accumulations of round and elongated nuclei in the endocardium. Not far from the free edge of the valve there was an oblong area where the tissue was very loose, did not stain with eosin, and contained a relatively large number of round, large nuclei. There were larger areas in the thin valve which appeared homogeneous and contained very few nuclei. The neighboring myocardium contained many small scars.

In the normal commissure there were accumulations of round cells in the loose tissue between the pulmonary valve and the aorta. The pulmonary valve appeared intact. The aortic valve was thickened and the nodulus calcified. The wall of the heart below the abnormal commissure contained nothing unusual. In the sections from the abnormal commissures, no inflammation was found. There were, however, some cellular aggregations in the pericardial fat.

Diagnosis.—Hypertrophy of the heart. Sclerosis of the coronary arteries, notably of the left circumflex branch. Recent thrombosis of right circumflex branch. Circumscribed myomalacia in outer and upper part of left ventricle. Abortive supernumerary cusp (congenital) of the pulmonary valve. General arteriosclerosis. Swelling of spleen. Swelling and fatty change in liver. Healed tuberculous focus in middle lobe of right lung. Submucous hemorrhages in small intestine. Submucous nodule in duodenum (aberrant pancreas). Myomata uteri.

DISCUSSION

The patient had essential hypertension which became "malignant." Sclerosis of the coronary vessels resulted in myocardial weakening and circulatory failure. Death came when the sclerotic coronary vessels became thrombosed. The only valvular lesion of the heart was the supernumerary cusp in the pulmonary valve. The apical systolic murmur was either functional in origin or was transmitted from the pulmonary valve. The apical diastolic sound was probably the third heart sound of gallop rhythm. The basal diastolic murmur and the enlargement of the pulmonary conus observed in the roentgenograms were caused by pulmonary insufficiency. The generalized enlargement of the heart shadow was due to hypertrophy and dilatation of the heart.

An important question must be answered. Did the presence of the supernumerary cusp in the pulmonary valve render the valve incompetent or was the cusp an adventitious finding? Longworth[82] in 1878 demonstrated that the optimum number of semilunar cusps is three. For maximum efficiency of the pulmonary valve, the cusps during systole should lie flat against the arterial wall whereas during diastole the segments should fall together and come in contact with each other as far as the center of the artery. To fulfil these two conditions the combined length of the free borders of all the cusps must equal the circumference of the artery and the length of each free border must equal twice the radius of the artery. Only if there are three cusps will both

conditions be fulfilled, inasmuch as three diameters (or more exactly π or 3.1416) equal the circumference. Two, four, five, or any other number of valvular segments can fulfil only one of the two conditions. (Fig. 5.) It may be said, therefore, that in the case here presented, the pulmonary valve did not operate at maximum efficiency.

At necropsy the pulmonary valve did not appear unquestionably incompetent, but during life it most probably was. Normally, the pulmonary ring is more distensible than the aortic ring (Gibson[80]), and it is likely in this case, since an inelastic pulmonary artery was found post mortem, that the pulmonic ring was stretched during life. The valvular anomaly probably permitted at the pulmonary orifice a slight degree of regurgitation which was negligible for many years until left ventricular failure developed and the pressure in the pulmonary circuit rose. As the pressure rose, the valve became increasingly incompetent.

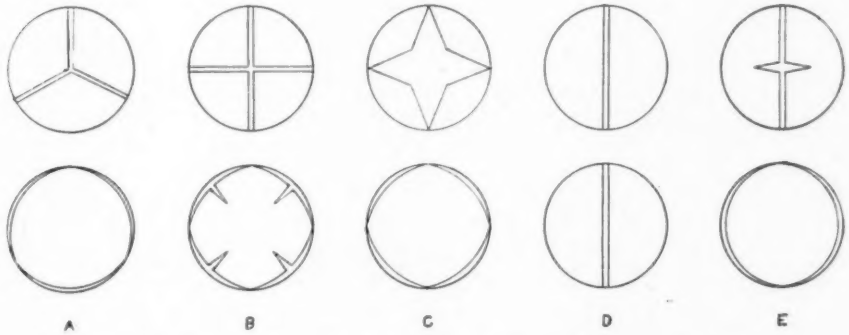

Fig. 5.—Influence of the number of cusps on efficiency of semilunar valve. Upper row, valve closed, lower row, valve open.

A, three cusps, efficient closure, efficient opening. Length of free border of each cusp equals two radii or one diameter. Combined lengths of free borders equal six radii or three diameters. Circumference also equals three diameters or more exactly, 3.1416 × diameter. When valve is closed, cusps are just long enough to meet in center without overlapping. When open, free borders fit closely against arterial wall without overlapping.

B, four cusps, efficient closure, inefficient opening. Combined length of free borders equals eight radii or four diameters. When valve is open, there is excess length of one diameter (more exactly, six-sevenths diameter) so that cusp borders overlap.

C, four cusps, inefficient closure, efficient opening. Combined length of cusps equals three diameters. Each cusp's length is only three-fourths diameter and cannot close up to center of artery.

D, two cusps, efficient closure, inefficient opening. Combined length of free borders equals two diameters. Cusps cannot move and valve cannot open.

E, two cusps, inefficient closure, efficient opening. Combined length of free borders equals three diameters. Each cusp's length is one and one-half diameters, an excess of one-half diameter for each cusp when valve is closed.

With beginning failure, while the pulmonary arterial pressure was still low, the degree of regurgitation was slight. During the last month of life, the murmur of pulmonary insufficiency became louder and louder because the degree of regurgitation increased. The left ventricle failed progressively, the pressure in the pulmonary circuit rose higher and higher, and the valvular ring dilated increasingly. At first,

while the circulation was still competent, the roentgenograms disclosed no enlargement of the pulmonary conus. Later, the pulmonary conus showed a moderate degree of dilatation. Still later, when the murmur was loudest and the regurgitation greatest, the conus was largest.

CRITERIA FOR DIAGNOSIS

The appreciation of a condition often leads to its recognition. The next case, it is hoped, will not be overlooked. In Pitt's series[84] of cases of pulmonary insufficiency assembled from the literature and from the records of Guy's Hospital, there were sixteen cases of pulmonary insufficiency associated with an abnormality in the number of pulmonary cusps. In six cases there were four cusps, in nine cases two cusps, and in one case five cusps.

It is clear from a study of the literature that four cusps in the pulmonary valve may occur without symptoms or signs of pulmonary insufficiency. It is quite likely that many of the cases reported as lacking signs were not examined for a diastolic murmur in the pulmonary area. In other cases, it is possible that regurgitation and a diastolic murmur were not present, although the valve was incompetent anatomically, because the pulmonary arterial pressure was lower than the right ventricular pressure.[84] At any rate, those cases which lack clinical evidence of the anomaly can be discovered only post mortem.

But there are cases with clinical manifestations of pulmonary insufficiency. In cases of pulmonary insufficiency, in the absence of another cause, such as bacterial endocarditis or mitral stenosis, a congenital anomaly, such as four cusps, or two cusps in the valve, may be suspected. Pulmonary insufficiency must be considered when a diastolic murmur is heard at the base of the heart in the absence of the peripheral signs of aortic insufficiency. When marked enlargement of the pulmonary conus is observed in the roentgenogram (Schwartz[86]), pulmonic incompetence is suggested. Fluoroscopic findings are often characteristic. There occurs a pulsation of the pulmonary artery—"the dance of the hiluses"[83]—comparable to the dynamic aorta seen in aortic insufficiency.

Pulmonary insufficiency is accompanied by hypertrophy and dilatation of the right ventricle and right auricle and often of the pulmonary artery itself. The tricuspid valve may become incompetent, with the evidence of a large pulsating liver and jugular reflux. Dyspnea may be extreme and disproportionate (Sansom[85]).

SUMMARY

1. A case of pulmonary insufficiency is described in which a loud diastolic murmur was heard at the base of the heart and in which four cusps in the valve were found at necropsy.

2. Review of the literature reveals that a supernumerary pulmonary cusp may occur without signs or symptoms. The anomaly may be associated, as in the case here presented, with pulmonary regurgitation.

3. The diagnosis has never been made ante mortem.

4. Three semilunar cusps are the optimal number. If there are four cusps (or two or five), the pulmonary valve cannot operate at maximum efficiency (Longworth[82]).

5. There are cases in which unexplained basal diastolic murmurs are present with no evidence of aortic insufficiency. It is suggested that some of these are due to an anomaly of the pulmonary valve.

* * * * *

I wish to acknowledge my indebtedness to the late Dr. Marcus A. Rothschild for his aid.

SUMMARY OF CASES OF FOUR PULMONARY CUSPS

1. a.* 13.181[1] Ref.: R.V.H. 21/98. Female, aged fifty-six years, who died of chronic nephritis and arteriosclerosis. Posterior segment little larger than others and sinus behind it is divided into unequal parts by delicate raphe 5 mm. from left corner. Raphe is half height of sinus.

b. 13.181[2] Ref.: 3959 F. 255/08. Male, three and one-half months old, who died of inanition. Heart small size and atrophic. Ductus arteriosus patent. Three cusps larger and of equal size; fourth narrower, about one-half width of others, fenestrated and dipped a little deeper into the heart musculature. Between left and right posterior cusps.

c. 13.181[3] Ref.: E. 7892 M.G.H. 192/22. Female, aged thirty-nine years. No cardiac symptoms. Died following operation for right hydronephrosis. Heart normal size. Tricuspid valve slightly abnormal—septal and infundibular cusps inserted directly into pars membranacea, leaving 6 mm. interval between them. Left auricle much smaller than right. Left ventricle hypertrophied. Mitral valve sclerotic. Right auricle capacious but not hypertrophied. Pulmonary artery larger than aorta, 7.2 cm. diameter. Cusps well formed, delicate fenestrated. Three segments equal, 2 cm. wide, fourth, 1.4 cm. Between anterior and right posterior cusps.

2. a. Male, aged thirty-six years, who died of a "compound heart defect." Dilated and hypertrophied heart. Incompetent aortic valve. Dilatation, ulceration, and atheroma of aorta. One cusp smaller than other three. Small cusp on posterior wall between right and left cusps. Larger cusps 3 cm. across, small cusp 2 cm. Large cusps 17 mm. deep, small one 7 mm. Large cusps semilunar shaped, small cusp funnel shaped, broader below. Each cusp possessed a corpus Arantii.

b. Female, forty-two years old, who died of pulmonary edema. Mitral stenosis. Hypertrophied and dilated heart. One of cusps small. All four fenestrated and had thickened corpora Arantii. Larger cusps 2.5 cm. across, smaller 1.5 cm. Depth of larger cusps 1.5 cm., of small 1.2 cm. Small cusp between anterior and right cusp. Small cusp a little swelled out below.

c. Male, twelve years old, who died of miliary tuberculosis. Two cusps half as large as other two. Larger ones each 2 cm. wide, smaller 1 cm. Depth of larger cusps 1.5 cm., of smaller 1 cm. One anterior cusp, one right, and two left (the smaller). Two smaller cusps partly fused together and attached to arterial wall only above and below. Each cusp possessed a corpus Arantii.

3. Picture of valve with four cusps, all fenestrated.

*The numbers correspond to the reference numbers.

4. Male, aged twenty-one years. Dyspnea on exertion. Systolic and diastolic basal murmurs. Right arm smaller than left from birth. Died of a fractured skull. Pulmonary valve slightly incompetent to water. Three cusps of ordinary size, fourth much smaller and imperfectly separated from one of other cusps.

5. Male, fifty-four years old. Nocturnal asthma and palpitation. Systolic and diastolic thrill. Systolic apical murmur. Diastolic murmur heard best in fourth left interspace. Died of "collapse" of the heart. Resolving lobar pneumonia. Hypertrophy of all heart cavities. Aortic valve and aorta atheromatous. Mitral cusps retracted. Pulmonary artery aneurysmal, circumference 3 cm. from origin measured 160 mm. Three cusps of equal and normal size, fourth smaller. Difference in size limited only to width; height and thickness equal to that of other three. Valve sufficient.

6. Male, aged fifty-seven years, who died of tuberculosis. Two anterior valvules larger. Two posterior valvules one-half less than others in size. All cusps reticulated. Right anterior cusp 21 mm. wide by 20 mm. deep, left anterior 21 by 26 mm., right posterior 14 by 15 mm., left posterior 13 by 13 mm.

7. Two cusps of equal size, third smaller, fourth very small, rudimentary, but perfectly formed with a corpus Arantii.

8. *Case 4.* Three cusps of equal size, 2 to 2.5 cm. wide, 2 cm. deep. Fourth cusp half as large, 1.2 cm. wide and 1.5 cm. deep.

Case 5. Moderate hypertrophy of left ventricle. Thickening, calcification, and insufficiency of mitral valve. Aortic valve thickened. Patent foramen ovale (size of lead pencil). Three cusps of same size, 1.5 to 2 cm. wide, fourth smaller, lying between right and anterior cusp. Free margin 0.7 cm. wide. From free margin to floor of pocket 1 cm.

Case 6. Right ventricular musculature relatively thick. Patent foramen ovale (size of lead pencil). Three cusps of equal size, 2 to 2.5 cm. wide, 1.5 to 2 cm. deep. Fourth cusp between anterior and left cusps; 0.3 cm. wide at top but increasing in width toward lower border, forming a narrow-mouthed pocket. All cusps adherent at tips. Insufficiency of valve.

9. No cardiac symptoms or signs. Death from tuberculosis. Fourth cusp between internal and posterior cusps. Like others except in size. After alcohol fixation, 10 mm. across, the others 24, 19, and 18 mm.

10. a. Female, aged thirty-six years. Patient epileptic. No cardiac symptoms or signs. Diffuse acute periencephalitis, atrophy of brain, acute croupous pneumonia, hyperemia of abdominal organs, atheroma of aorta. Three cusps equally large, 1.5 cm. wide, fourth one-half the size. All cusps fenestrated along free margin, small cusp more than others.

b. Male, sixty-four years old. In his last years suffered from shortness of breath on the slightest exertion. No physical examination of the chest before death. Large heart. Left ventricle dilated, walls thickened. Right ventricle enormously dilated, wall greatly thickened. Aorta atheromatous. Atrophy and edema of brain, edema of lungs, hyperemia of spleen and kidneys. Three cusps about same size and shape (2 cm. wide), fourth half that size. All cusps fenestrated, fourth more than others.

11. Male adult. No cardiac signs. Died from gangrene of the lung. Fourth cusp between right anterior and posterior segments, similar to others in shape but much smaller. Depth one-third that of others, breadth one-fifth that of others. No corpus Arantii. Sinus communicated with sinuses of neighboring cusps. Valve competent.

12. Male, sixteen months old, who died of bronchopneumonia. Supernumerary cusp situated a little below level of attachment of other cusps. Distinct corpus Arantii.

13. Description of case not available.

14. Male, eighty years old. Occasional attacks of weakness. Mitral regurgitant murmur. Aortic sounds double. No definite history of a tricuspid murmur. Heart enlarged, weighed 27 ounces filled with blood. Aortic valve incompetent to water. Walls of right ventricle thin. Pulmonary artery enlarged. Valve incompetent to water. Circumference of artery just above valve, 9 cm.; broadest portion of artery just before bifurcation, forming a pouch 14 to 16 cm. in circumference. Four perfect cusps.

15. a. Three of curtains well formed, but there was an additional sigmoid pouch capable of holding a pea.

b. Septum between two of the cusps longer than others.

c. Very minute, imperfectly formed additional cusp formed by a little curtain supported above by slender cords.

d. Still more minute extra cusp not only attached laterally to the artery by tendinous cords, but also presenting a thin membranous bridle which extended upward from that portion of the free edge at which the corpus Arantii is usually situated to the arterial wall above.

e. Four perfectly formed symmetrical leaflets.

16. Fourth cusp about one-third size of normal cusp and situated between two posterior cusps.

17. Male, thirty-two years old. No cardiac symptoms or signs during last illness. Death from acute nephritis complicated by pleuritis and compression of the lung. Three cusps of equal size; fourth, one-half width of others, situated between anterior and posterior cusps. Two adjacent cusps fenestrated. Rudimentary fourth cusp filled in defects of other two cusps. Fourth cusp shorter than others and lay on a lower level. Margin held in place by two long thin fibrous strands stretching from near its center to angles of attachment of two adjacent cusps.

18. a. Male, four years old, who died of postdiphtheritic myocarditis and serofibrinous pleurisy of left lung. Each cusp about 9 to 10 mm. across and 8 to 9 mm. high. In all respects normal. Small fenestration on each cusp.

b. Female, seventy-eight years old, who died of bilateral bronchopneumonia with left fibrinous pleurisy. Left anterior cusp 18 mm. wide and 18 mm. deep; right anterior 20 by 16; right posterior 14 by 12; left posterior 14 by 12. Two posterior cusps fenestrated at angle of insertion.

c. Female, twenty-seven years old, who died of miliary tuberculosis. Hypoplastic heart and aorta. Three cusps of equal size and larger than fourth as follows: 15 mm. wide and 13 mm. deep; 16 by 12; 15 by 12; 6 by 5. Cusps of uniform thickness throughout, there being no thinning along lunula and no corpora Arantii. Fourth cusp fenestrated.

d. Male, nine years old. Faucial diphtheria. Bilateral bronchopneumonia. Three cusps of approximately equal size: one 14 mm. wide and 12 mm. deep, second 15 by 12, third 14 by 11. Fourth smaller, 8 by 7 mm. and on a lower plane than the others.

e. Male, forty-eight years old. Adherent pericardium, enlarged heart, particularly left ventricle and left auricle. Aortic stenosis and insufficiency. Dilated right ventricle. Pulmonary edema, chronic passive congestion of splanchnic viscera. Anterior cusps larger and equal: left anterior 18 by 14 mm., right anterior 19 by 14; posterior cusps smaller and almost equal: right 14 by 14, left 15 by 13. Left anterior fenestrated.

19. Male, forty-eight years old. Normal heart rhythm. No murmurs. Died of uremia. Small sclerotic kidneys. Emphysema and chronic bronchitis. Left ventricle hypertrophied. Aortic valve sclerotic and thickened. An anterior, a posterior cusp, a

right and left lateral. Posterior 25 mm. wide and 10 mm. deep, anterior 21 by 11 and had a corpus Arantii, left 25 by 19. Posterior valvule like Bernard's case. Pulmonary orifice 97 mm. in circumference.

20. a. Adult. Diffuse atheroma at beginning of aorta and mitral and aortic valves. Patent foramen ovale but with a sufficient valve. Three cusps larger, 18, 20, 22 mm. wide and 13 to 15 mm. deep; fourth, between posterior and right, 8 mm. wide and 10 mm. deep.

b. Adult. In right auricle at site of foramen ovale, an invagination 5 mm. deep but not communicating with left auricle. Three cusps 18 to 20 mm. wide and 13 to 17 mm. deep. Supernumerary cusp between posterior and left; 10 mm. wide and 12 mm. deep.

c. Adult. Supernumerary cusp between posterior and right cusps, 12 mm. wide. Other three, 20 to 23 mm. wide and 15 mm. deep.

d. Adult. Width of cusps, 13, 17, 18, and 25 mm., respectively. All 15 mm. deep. Supernumerary cusp between right and left.

21. a. Male, sixty years old. Tuberculosis of osseous system. Fourth cusp between left and anterior cusp, small.

b. Male, fourteen years old. Fourth cusp between right and left cusps, small.

c. Male, sixty-two years. Two cusps a bit larger than the other two which were somewhat grown together.

d. Small cusp between right and left cusps.

e. (No data on other five cases.)

22. a. Male, one year old. Atelectasis of lungs, intestinal catarrh, and rickets. Fourth cusp smaller. Communicated with neighboring cusps. Dilatation of pulmonary artery and right ventricle.

b. Male, fifty-two years old. Chronic pneumonia, miliary tuberculosis and vertebral caries. Fourth cusp very small and fenestrated.

23. Male, old. Extra cusp 1 mm. less in height than other three but otherwise just like them.

24. Male, thirty-one years old. Died from hemorrhagic apoplexy. Slight atheroma of aortic arch. Fourth cusp somewhat smaller than its fellows and communicated with one of them at its insertion by an aperture large enough to admit a crow quill. No corpus Arantii.

25. No heart disease. Supernumerary cusp much smaller than others but presented same configuration.

26. Male, fifty years old. Died from phthisis. Heart normal. Each of cusps well formed and possessing corpus Arantii. Three equal sized, fourth scarcely half breadth of others.

27. Male, who died of typhus fever. Incompetency of tricuspid valve diagnosed during life. Three cusps about same size, fourth considerably smaller than others and with an inconspicuous corpus Arantii. All four cusps fenestrated. Fenestrations larger in small cusp.

28. Large heart. Right ventricle somewhat dilated. Patent foramen ovale (2 cm. diameter). Rudimentary supernumerary aortic cusp. Diameter pulmonary artery 9.3 cm. Width of anterior and left posterior cusp, each 3 cm. Right posterior, 2.5 cm. wide and 1.5 cm. deep.

29. Patient died of typhoid fever. During life there was heard a murmur which replaced the first sound and lasted until almost the beginning of the second. Four valvules in pulmonary artery, of normal shape.

30. See Reference Number 4.

31. Well marked presystolic murmur. Case with four pulmonary cusps similar to Coleman's.[16]

32. Two cases with four pulmonary cusps.

33. Manuscript not available. (Reference not checked.)

34. Female, old. Circumference of pulmonary artery 3⅛ inches. Three of cusps measured 1 inch wide, fourth ⅛ inch. Supplementary cusp resembled others except in size. Corpus Arantii present. Fourth cusp reticulated.

35. a. Male, nineteen years old, who died of cancer and tuberculosis of the lung. Two valvules of equal and normal size and appearance and one large valvule, attached border of which was imperfectly doubly crescentic. A little to one side of center of free border of cusp was a single very large corpus Arantii. From this body a septum proceeded dividing the cusp in two compartments.

b. Heart identical anatomically with above.

c. Three valvules of nearly equal size. Between two of these, a fourth smaller cusp with its own corpus Arantii.

36. All three patients died of disease not related to the anomaly.

a. Three larger cusps and one smaller. Supernumerary cusp between anterior and right lateral cusps was half the width and half the depth of other three cusps. No nodule of Morgagni. Tendinous cords from lateral margins of cusp to arterial wall. All cusps but one fenestrated.

b. Supernumerary cusp half height and width of other three. Situated between anterior and left lateral cusps. No nodule of Morgagni. Intravalvular pocket at its base. All cusps communicated with one another. Fibrinous cords at commissures. Fenestration of cusps at commissures.

c. Two normal-sized cusps and two half their depth and width. Two smaller cusps equal in size. They replaced right lateral cusp. Many fenestrations. Communication between smaller cusps below and larger ones above.

37. In six cases, the right septal cusp was subdivided, the left also in six, so that in each of twelve cases there were four cusps.

38. Female, sixty years old, who died of ruptured aneurysm of iliac artery. Always sickly. Systolic apical murmur. Accentuated second pulmonic second sound. Thyroid enlarged. Heart enlarged, especially right auricle. Thickening of mitral valve, no narrowing. Stiffening of aortic valve but no insufficiency. Dilatation of pulmonary conus. Small fourth cusp between right and left cusps, its free border being at level of lower surface of neighboring cusps. Two bands of tissue ran from middle of its free border to sinus border.

39. Female, thirty-four years old. Suffered from palpitation of the heart, pain in the chest and difficulty in breathing. Cyanosis, intense dyspnea, ascites, edema of lower extremities. Systolic and diastolic murmurs over pulmonary area. Heart enlarged. Right auricle dilated. Patent foramen ovale. Right ventricle enormously dilated, trabeculae hypertrophic. General anasarca. Pleural effusion. Purulent bronchitis. Congestion of liver, spleen, and kidneys. Conus arteriosus very wide, likewise pulmonary artery. Right and left posterior, and right and left anterior cusps. Left posterior cusp very small, free border about 4 "linien"* wide. Other cusps each 6 to 8 "linien" wide.

40. Male, fifteen years old. Signs of mitral and aortic insufficiency and of pulmonary tuberculosis. Acute pericarditis, mitral and aortic insufficiency. Pulmonary tuberculosis. Two cusps larger, two smaller.

41. Male, six years old. Systolic thrill over precordium. Systolic murmur along left border of sternum heard best between third and fourth ribs. Second pulmonic sound greatly accentuated. Slight dilatation and hypertrophy of heart. Aneurysm and endocarditis of aortic valve. Patent interventricular septum and foramen ovale. Bronchopneumonia. Three cusps each 1.5 cm. wide, fourth 3 mm. wide.

42. One cusp much smaller than the other three.

*One "Linie" = 2.195 mm.

43. Male, sixty-one years old. Palpitation and dyspnea on effort. Pulse rate 27, bigeminal. Systolic basal murmur in pulmonary area. Emphysema. Cyanotic. Heart weight 520 gm. Wall of left ventricle hypertrophied. Aortic valve slightly indurated but otherwise normal. Right auricle and ventricle thin and diminished in size. One cusp, left and a little anterior, 1.9 cm. wide and 1.7 deep, with corpus Arantii. Second, anterior and a little to right, 1.4 by 1.6 cm., shrivelled and plaited, with no nodule. Third, posterior and right, 2 by 1.8 cm. Fourth, posterior and left, 2.5 by 2.1 cm., with vestige of corpus Arantii.

44. a. History not obtained. Pulmonary artery quite wide. Four well-built cusps. Anterior and right cusp each 2 cm. wide, other two 1.5 cm. across. All had corpora Arantii. Upon right cusp, a sinewy thickening, 2 to 3 mm. wide, parallel to upper border. Similar thickening below nodule of left cusp. This cusp had a small fenestra. Fourth cusp free of defects but had marked fibrous thickening along free border.

b. History not obtained. Heart atrophied. Muscle fatty. Wall of right ventricle thin. Patency of intra-auricular septum. Three cusps normally built, fourth rudimentary, between posterior cusps. Three larger each 20 mm. wide, smaller 8 mm. Large cusps 17 to 20 mm. deep, small one 6 mm. Free border of latter ran upward and to right in a thin fibrous cord leaving a space about the size of a millet seed between itself and the cusp.

45. a. Female, sixteen years old, who died of chronic nephritis. Two cusps of equal size and normal. Between these two were two others, a little larger, of equal size, possessing rudimentary corpora Arantii.

b. Male, forty-four years old, who died of pulmonary tuberculosis. One cusp 22 mm. wide by 18 mm. deep, well formed and with corpus Arantii. Second, 25 by 21 mm., without corpus Arantii. Between two preceding cusps, two others fused together, larger of which was 24 by 19 mm., smaller 14 by 13 mm. Along free margin was a fibrous cord attached obliquely to arterial wall and which inserted above smaller cusp. Another rudimentary lower cord. Smaller cusp fenestrated.

46. All cases past puberty. No subjective symptoms or signs related to the anomalies in any case.

Case V. Heart enlarged. Right auricle larger than normal. Right ventricle much larger than left. Heart infiltrated with fat subpericardially. Two larger cusps, anterior, two smaller, posterior. All cusps had nodule of Morgagni.

Case VI. Right ventricle thin. First cusp, 15 mm. wide by 10 deep. Second, 20 by 14 mm., free border curved, convexity upward. Third, 13 by 9 mm. Fourth, supernumerary cusp, placed in angle formed by insertion of two adjacent cusps. Valvule not attached directly to arterial wall but to adjoining valvules. Four very fine bands of tissue running from free border, inserting in space between points of insertion of free borders of adjacent cusps. Length of free border of supernumerary cusp 4 mm., height 3 mm. All cusps lacked nodule of Morgagni.

Case VII. Heart larger than normal, left side more than right. Slight thickening of mitral valve. Three cusps of equal size and normal. Fourth not as deep as others nor as high. Two bands running from fourth cusp to arterial wall. Height of fourth cusp 8 mm., width 10 mm., others 16 by 28 mm.

47. In his (Meckel's) father's collection were four cases of hearts with four pulmonary cusps. First case showed a single large cusp and other three equal but much smaller. Second and third cases, one very large cusp, two a little smaller, the fourth much smaller than usual. Fourth case showed three cusps of equal size and normal; fourth cusp was very small; scattered small fenestrae in all cusps, and none had nodule of Morgagni.

48. Five cases noted, including the four cases given as under No. 47. One, three cusps lacked a little of the usual size, but the fourth was very small (discovered by

Meckel, senior). Two, two cusps a bit smaller but equal, third of normal size, fourth smallest (discovered by Meckel, senior). Three and four, the son had two more cases almost exactly like second case. Five, no two cusps equal, but sizes decreased in order.

49. a. Female, eighty-five years old. Four cusps of equal size. Extra cusp between right and left. Left and supernumerary cusps joined together at commissure. Right cusp projected 3 mm. above level of other cusps. Corpora Arantii all well developed. Patent interventricular septum.

b. Male, eighty-three years old. Extra cusp between right and left, smaller than its neighbors. Free border 8 mm. All four cusps fenestrated. Patent interventricular septum.

50. Three cases seen. In one, all cusps were of approximately equal size.

51. Female, thirty-nine years old, who died of intestinal obstruction due to strangulated femoral hernia. No disorder related to the circulation. Peritonitis. One cusp larger than others, anterior and to left of others.

52. No features of special interest among symptoms and signs. Cusps well formed, measuring 2, 1.8, 1.8, and 1.4 cm. respectively, along free border. Largest one a little thickened. All fenestrated.

53. a. No clinical manifestations. Supernumerary cusp 8 mm. wide and 8 mm. deep. No corpus Arantii. Anchored to wall of artery by small narrow tag. Lateral attachments to adjacent cusps, not artery. Two or three fenestrations of large cusps communicated directly with fenestrations of small cusp. Three larger cusps of equal size and normal.

b. Small supernumerary cusp 7 mm. wide and 8 mm. deep. Lateral edges united to contiguous cusps. Sinus distinct and did not communicate with adjacent sinuses. Adjacent cusps smaller than third.

54. Eight cases.

55. Male, forty-six years old, who died of chronic phthisis, with genitourinary complications. Heart somewhat increased in size and weight (9 ounces and 14 drams). Cavities of large size and walls moderately thickened. Two smaller cusps formed by division of one larger cusp.

56. First cusp to right, second and third toward center posterior, fourth left. Third cusp much smaller than others, finer in structure and reticulated. Each cusp had corpus Arantii placed in center.

57. Double ascending aorta. Three cusps larger, fourth very small.

58. a. Four cusps, 10, 20, 21.5, and 20 mm. in width.

b. Four cusps, 17, 9, 20, and 15 mm. in width.

c. Hypertrophy of left ventricle. Aortic insufficiency and stenosis. Four cusps, 23, 14, 13, and 18 mm. in width.

d. Much calcification of aorta. Hypertrophy of left ventricle. Four cusps, 17, 25, 15, and 6 mm. in width.

e. Author mentioned two more cases but gave no data.

59. Female, thirty-one years old. On eleventh day after cholecystectomy, sudden distress developed with marked dyspnea, cyanosis, and rapid pulse. Severe right heart dilatation with bulging of auricle and venae cavae. Weight 290 gm. Myocardium flabby, with slight fatty infiltration particularly in right ventricle. Slight thickening of mitral and aortic valve leaflets. Fourth cusp small and appeared to be derived from anlage of left posterior cusp. Small cusp fenestrated and had no corpus Arantii.

60. Male, seventeen years old. Four well-shaped leaflets, 13, 17, 14, and 16 mm. in width. Two middle leaflets at line of junction joined to arterial wall by wedge-shaped bridge of fibrous tissue which acted as a partition and divided the whole cusp in two. Partition perforated near top. Only first, second, and fourth cusps had corpus Arantii, third had only small condensation near middle.

61. *Case VII.* Female, old. No symptoms. Died of enteroperitonitis. Three of cusps each 15 mm. wide, fourth 18 mm.

Case VIII. Male, fifty-five years old. Abscess of leg. Empyema. Two of cusps 15 mm. wide, third 13 mm., fourth 8 mm. In each of the two larger ones, rather than a corpus Arantii was an enlargement of median part of free border. Other two cusps, no trace of corpus Arantii.

Case IX. Male, fifty years old. Heart larger than normal through marked hypertrophy of left ventricle and auricle. Thickening of endocardium of mitral valve by a mild chronic endocarditis. Aortic valve, insufficient and stenosed. One cusp 19 mm. wide and 10 high, second 13 by 10 mm., third 14 by 14 mm., fourth 16 by 15 mm.

62. Cusps intact. Supernumerary cusp one-half size of others.

63. Male, fifty-seven years old. No clinical history. Sudden death. Left ventricle hypertrophied. Mitral and aortic valves moderately thickened. Coronary arteries sclerotic. Aorta atheromatous. Two cusps were each 2 cm. wide, the two others together measured 2 cm. No corpus Arantii on smaller which was 8 mm. wide by 6 mm. deep, and fenestrated near free margin. Larger of two 14 mm. wide by 10 mm. deep, had no corpus Arantii either. Two larger cusps had corpus Arantii.

64. a. Female, forty-four years old, clinical signs of mitral stenosis. Necropsy revealed mitral stenosis. Four equal sized cusps.

b. Female, fifty-four years old. Pulmonary tuberculosis. Four equal sized cusps.

c. Male, forty-eight years old. Tuberculosis of elbow. Four equal sized cusps.

d. Male, forty-six years old. Senile brain atrophy. One of cusps of small size.

65. a. Female, sixty-four years old. Extra leaflet between posterior and left leaflets, 1 cm. wide, other cusps of normal size.

b. Male, seventy-six years old. Cusps arranged as anterior, posterior, internal, and external. Of about equal size.

66. a. Cusps of equal size but little smaller than usual.

b. Two larger, one middle-sized, and one small cusp.

67. a. Male, sixty-five years old. Marked hypertrophy of both ventricles of heart. Pulmonary emphysema, arteriosclerosis, old cerebral apoplexy, cirrhosis of liver. Between anterior and left cusp, a rudimentary weak fourth cusp.

b. Female, thirty-seven years old. Hypertrophy of heart. Tuberculosis, cirrhosis of kidneys. Three cusps of equal size, fourth somewhat smaller, between anterior and right cusps.

c. Male, fifty-one years old. Four equal sized, delicate cusps. Three fenestrated.

68. Male, thirty-eight years. Ascending stairs caused palpitation of heart. Two years before death had "black fever" and from this time became drowsy and livid. Distended jugular veins. Rapid, feeble pulse. Weak heart impulse. First sound shorter and more flapping, second less distinct than normal. No murmurs. Anasarca. Erysipelas and gangrene of leg. Pericardial, pleural and peritoneal effusion. Heart enlarged. Right ventricle divided in two portions by an imperfect septum. Right auricle twice as thick as left. Columnae carnae of left ventricle small compared with right. Cusps of equal size. Each furnished with a corpus sesamoideum. Each cusp 0.9 inch in width. Circumference of pulmonary artery 1 inch greater than that of aorta. Dilated pulmonary conus.

69. Small supernumerary cusp between anterior and right cusp. Fenestrated.

70. Female, thirty-two years old, who died of carcinoma of breast. Marked dilatation of right ventricle. Left cusp replaced by two small separate cusps. Two larger cusps thickened along free margin.

71. Female, five months old. Child brought to hospital with sickness and diarrhea. No cyanosis. Loud diffused systolic murmur. Recent endocarditis tricuspid valve. Foramen ovale two-thirds closed. Right ventricle dilated and hypertrophied. Bicuspid aortic valve. Patent interventricular septum. Patent ductus Botalli. Cusps thickened and having many small granulations. Pulmonary artery expanded up to bifurcation.

72. Male, fifty-six years old. Enlargement of heart, mostly left side. Marked hypertrophy of right side. Mitral valve a little thickened. Chronic endaortitis from arch to bifurcation, but no dilatation. Aneurysm of splenic artery. Dilatation of pulmonary conus and artery. Lowering of left posterior cusp caused incompetency of valve. Thickening of other cusps. A fourth cusp, small, recognized by a special small sinus of Valsalva.

73. Female adult. Died in sixth month of pregnancy following cardiopulmonary complications. Heart larger than normal. Right auricle much larger than left. Right ventricle dilated. Buttonhole mitral stenosis. Cusps well developed and closed well. Most internal cusp, near septum, largest in size, 22 mm. wide and 16 mm. deep. Proceeding to right, next cusp 19 by 12 mm. Third, 14 by 10 mm.; fourth, 17 by 13 mm. Last two fenestrated. Orifice of pulmonary artery at margin of insertion of cusps, 100 mm.

74. Female, forty-two years old. Articular rheumatism at age of twenty-seven years. Auricles and ventricles normal. Cusps of different sizes, all in excellent condition. Cusp most to left largest—34 mm. wide by 18 mm. high. Proceeding right on posterior wall of artery, second cusp 21 mm. by 15, third 18 by 7 mm., fourth 23 by 16 mm. Cusps fenestrated. Nodule of Morgagni in each perfectly developed.

75. a. Male, aged fifty-eight years, who died of pneumonia. Adherent pericardium. Large flabby heart. Fourth cusp very small, between anterior and left cusp, 8 mm. wide and 7 deep. Other cusps each 20 mm. wide and 15 mm. deep.

b. Female, aged sixty-four years, who died of uterine carcinoma. Four cusps situated like above mentioned case.

76. a. Male, eighteen years old. Chronic rheumatic endocarditis of mitral valve. Subacute bacterial endocarditis. Four cusps.

b. Female, aged forty-three years. Lobar pneumonia. Chronic pulmonary tuberculosis. Hypoplasia of left auricle and ventricle. Dilatation of right auricle and ventricle. Four cusps. Fibrous thickening at margin of pulmonary valve. Dilatation of pulmonary artery (10 cm. in circumference).

c. Male, fifty-four years old. Peritonitis following appendectomy. Slight hypertrophy of left ventricle. Small extra cusp between two anterior cusps.

d. Female, ten years old. Carcinoma of jaw. Slight hypertrophy left ventricle. Small additional cusp between left anterior and posterior cusps. Pulmonary stenosis. Thickening and fusion of all cusps of pulmonary valve.

77. Female, middle-aged. Heart hypertrophied, especially right side. Three cusps of normal size. Fourth like others in contour and formation, but smaller, being both narrower and less deep. Leaflets thinned at lunula and fenestrated.

78. Male, fifty-five years old. No physical signs of pulmonary valvular disease. Granular and fatty degeneration of kidneys. Anasarca. Heart weighed 25½ ounces. Both ventricles dilated, right greatly. Wall of left considerably, that of right slightly thickened. Aortic cusps thickened and calcified. Three cusps normal in appearance and equal. Fourth between posterior and right lateral segments, somewhat less than one-half width of others but of nearly same depth. Elongated slit-like fenestrations near edge. Sinus of fourth cusp communicated with that of posterior cusp.

79. One cusp much smaller than the others.

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Department of Clinical Reports

THE IMPORTANCE OF RIGHT AXIS DEVIATION IN THE DIAGNOSIS OF PULMONARY STENOSIS*

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THE greatest degree of right axis deviation in the electrocardiogram is seen in cases of congenital pulmonary stenosis. This fact has been recognized since the pioneer work of Einthoven. A corollary of this, that in the absence of right axis deviation a diagnosis of congenital pulmonary stenosis should be questioned, was confirmed by the autopsy findings of a case seen in consultation at the San Diego County General Hospital.

CASE REPORT

The patient, a boy twelve years old, had always been well except for scarlet fever at eight and diphtheria at nine years of age. When he was eight years old, before the attacks of scarlet fever and diphtheria, his parents had been told that he had "heart trouble," but no further information as to the nature of the cardiac lesion could be obtained. He had not had rheumatic fever. There had been no symptoms of cyanosis or of dyspnea.

The onset of the present illness, nineteen days before admission to the hospital, had been sudden and was characterized by general malaise, headache, nausea, vomiting, and fever. These symptoms had persisted and for the last week he had suffered also from dyspnea and palpitation of increasing severity.

Upon admission to the hospital the patient presented the picture of an acute fulminating bacterial endocarditis. The temperature was 104.6° F.; the pulse rate, 140; and the respiratory rate, 64. Cutaneous and conjunctival petechiae were present. Resonance was diminished over the bases of both lungs, and many coarse râles were heard over both lower lobes; roentgen ray examination revealed multiple areas of mottled infiltration throughout both lungs and passive congestion of the lower lobes. The left border of cardiac dullness extended 9 cm. from the midline. A palpable systolic thrill was present over the second interspace just to the left of the sternum, and a loud systolic murmur was heard over the entire precordium, of maximum intensity over the same area. The pulmonic second sound was present, however, and even somewhat accentuated. A teleroentgenogram showed the right border of the heart extending 5 cm. from the midline, and the left border, 8.8 cm. The internal diameter of the chest was 24 cm. The electrocardiogram showed a regular sinus rhythm with a rate of 140; the P-R interval, 0.15 sec.; the QRS interval, 0.05 sec.; and no abnormal axis deviation or other abnormalities (Fig. 1). The abdomen was slightly distended. There was no enlargement of the liver or spleen. The blood count revealed a moderate grade of anemia and marked leucocytosis (erythrocytes 3,790,000; hemoglobin, 68 per cent [Newcomer]; leucocytes, 27,000, of which 89 per cent were neutrophiles and 11 per cent lymphocytes). Blood culture yielded a growth of staphylococci.

*From the Rees-Stealy Clinic.

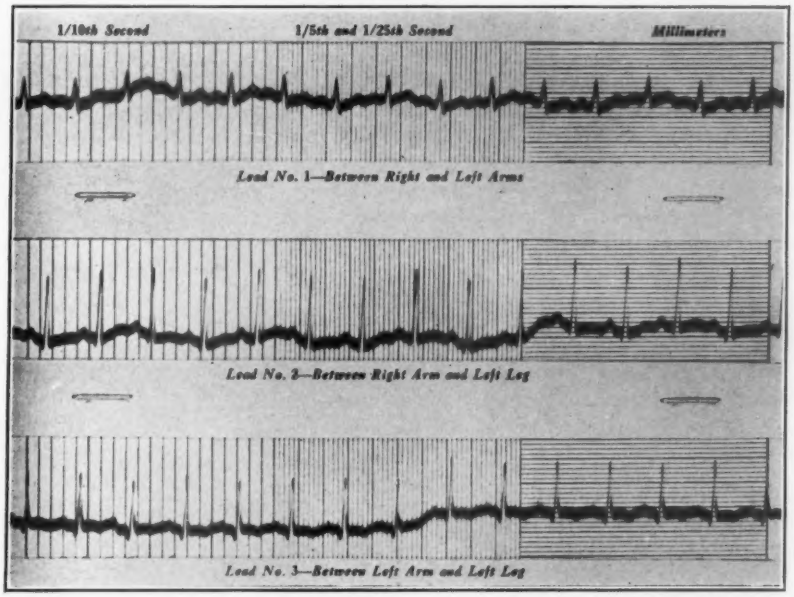

Fig. 1.—Electrocardiogram taken two days before death showing normal electrical axis. There is flattening in Lead II and inversion in Lead III of the T-waves but no significant abnormality except sinus tachycardia.

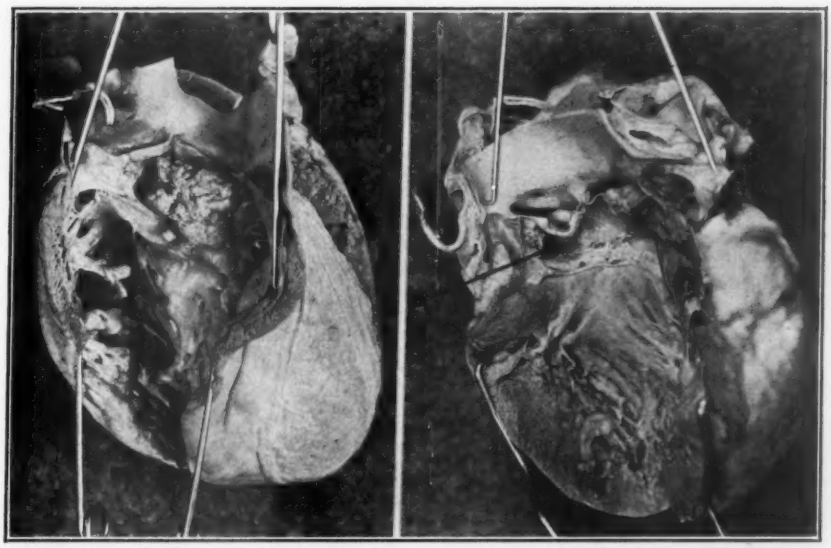

Fig. 2. Fig. 3.

Fig. 2.—The chamber of the right ventricle showing the cauliflower-like mass of vegetations arising from the margins of a defect in the membranous interventricular septum and extending into and almost filling the pulmonary infundibulum and pulmonary valve orifice. The pulmonary valve is normal.

Fig. 3.—The chamber of the left ventricle showing a congenital defect (*A*) in the membranous interventricular septum. The abnormal opening is almost filled with vegetations of acute bacterial endocarditis. The aortic valve is normal.

The patient's condition grew progressively worse, and he died on the fourth day after admission to the hospital.

The essential findings at autopsy were the petechiae of the skin and beneath the capsules of the kidneys, multiple small septic infarcts of both lungs, and the cardiac findings. The heart weighed 210 gm. There was moderate hypertrophy of the left ventricle and slight hypertrophy of the right. A cauliflower-like mass of vegetations was found almost to occlude the pulmonary valve orifice, but with no attachment to the valve or to the pulmonary infundibulum (Figs. 2 and 3). The vegetations arose from the margins of a defect in the membranous interventricular septum, practically filled the opening, and extended into the left ventricle for about 2 mm. All of the valves were normal, and there was no other endocardial involvement.

DISCUSSION

A clinical diagnosis of congenital pulmonary stenosis complicated by acute bacterial endocarditis had been made in this case. The presence of an abnormal communication between the right and left sides of the heart was suspected because of embolic phenomena of both the systemic and pulmonary circulations, but the chief reason for doubting the correctness of this diagnosis was the normal electrical axis of the electrocardiogram. It was felt that a diagnosis of congenital pulmonary stenosis was incompatible with the absence of right axis deviation in the electrocardiogram. This opinion was confirmed at autopsy when the cause of the systolic murmur and thrill over the pulmonic area present during life was found to be not stenosis but almost complete occlusion of the pulmonary valve orifice by a mass of vegetations. These vegetations arose from bacterial endocarditis of a congenital interventricular septal defect. The predilection for a congenital lesion as a site of invasion by bacterial infection, rather than normal valves or endocardium, is shown by the findings in this case. The pulmonary valve was not involved by the infection in spite of its proximity. A condition of functional stenosis of the pulmonary valve which must have caused an appreciable degree of right ventricular strain was present during the terminal illness. However, insufficient time had elapsed between the onset of the bacterial invasion and the fatal termination of the disease (twenty-three days) to result in any remarkable hypertrophy of the right ventricle. This explains the normal electrical axis shown in the electrocardiogram.

SUMMARY

A case of acute bacterial endocarditis complicating a congenital defect in the interventricular septum is reported. The physical findings of pulmonary stenosis were explained at autopsy by a mass of vegetations which almost completely filled the pulmonary valve orifice but which arose from the margins of the interventricular septal defect. The inaccuracy of a diagnosis of congenital pulmonary stenosis in the absence of right axis deviation in the electrocardiogram is illustrated by this case.

TRAUMATIC RUPTURE OF A NORMAL AORTIC VALVE*

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A REVIEW of the literature to the year 1928 by Howard[1] revealed 113 cases of ruptured aortic valve as the result of muscular effort or trauma; the first case was reported in 1830 by Plenderleath.[2] Of this entire group only forty-seven cases were due to trauma and of these there were only fourteen[3-16] that were proved by autopsy. A search of the literature up to the present time failed to reveal any additional cases of the proved traumatic group, therefore the one here reported makes a total of fifteen cases and is the third reported in America.

CASE REPORT

K. S., a single white male, aged twenty-two years, with a negative family and past history was injured in an explosion during the construction of the Ohio State Office Building on April 14, 1932. He was completely buried by stone and débris which caused the following external injuries: a comminuted fracture of the left forearm, compound fracture of the left leg, fracture into the left antrum, laceration of the left hip, laceration of the right hand, contusion of the left eye and side of face, fracture of the sternum, and discoloration of the entire anterior and posterior thorax due to contusions.

In an unconscious state he was admitted to the hospital where he received the necessary surgical attention, and on regaining consciousness he first complained of pain at the site of the compound fracture of the left leg, but within a few minutes he described a crushing sensation in his left chest associated with severe dyspnea. Five weeks following the injury he had an elevation of temperature for seven days, which was due to slight infection in his left leg. The recovery from his external injuries was good, and in December, 1932, he was discharged from the hospital, but all during this time he continued to have the crushing sensation in the left chest, moderate dyspnea which became severe on exertion, moderate palpitation on exertion, frequent attacks of syncope, severe dizziness, and anxiety with a fear of impending death. During these attacks of severe dizziness and syncope he would first become pale and then develop cyanosis of the lips and fingernails. He had a low grade infection in the left antrum which had been fractured, but it responded very well to treatment. In June, 1933, he was again admitted to the hospital because of signs of heart failure, and a pain in the right kidney region. Two days later, on June 16, 1933, death due to heart failure occurred.

This patient was known personally for ten years prior to his injury and had frequently been examined, the last time on Dec. 2, 1930, when he was found normal in every respect, with a normal, regular heart and a blood pressure of 120 mm. systolic and 76 mm. diastolic.

Cardiologic examination two days before death revealed engorgement of the neck veins, marked swinging of the carotid arteries, and a marked pulsation in the suprasternal notch. The apex beat was not palpable, and the cardiac dullness in the fifth interspace was 10 cm. to the left of the midsternal line, and in the fourth

*From the Cardiological Departments of White Cross and Children's Hospitals and the Medical College of Ohio State University, Columbus, Ohio.

interspace 5 cm. to the right of the midsternal line. There was a loud rough diastolic murmur heard at the base of the heart and along the left border of the sternum, with the maximum intensity at the aortic area. There was also slight roughness of the first sound at the apex. The rhythm of the heart was regular, and the rate was 96. The pulse was of the Corrigan type, and the blood pressure was systolic 110 mm., diastolic 20 mm. The liver edge was at the costal margin and not tender. There were many moist râles in the bases of both lungs. The urine contained a large amount of albumin, no sugar, but many red blood cells and pus cells, and the blood count showed 80 per cent hemoglobin, R.B.C., 4,320,000, W.B.C., 15,200. Orthodiagram showed the transverse diameter of the heart to be 15.5 cm. The Wassermann reaction was negative. The diagnosis was traumatic heart disease, ruptured aortic valve, aortic insufficiency, myocardial insufficiency, and heart failure—with, as an associated condition, possible embolism into the right kidney.

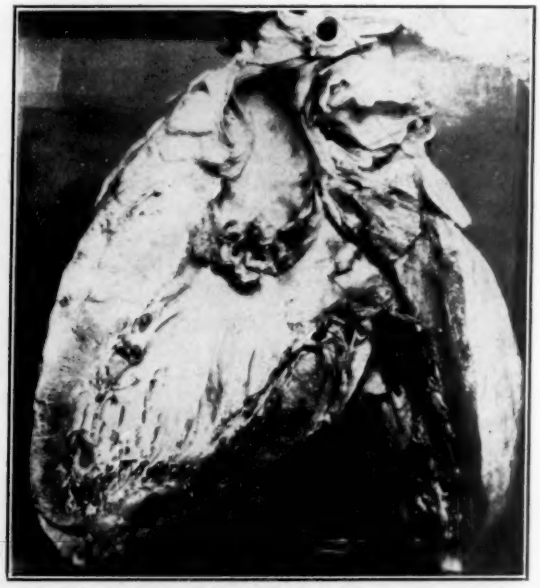

Fig. 1.—Ruptured and fragmented cusps of the aortic valve.

Autopsy.—The body was that of a well-developed and fairly well-nourished white man, measuring 67½ inches in length and estimated to weigh about 160 pounds.

After dissection of the superficial tissues from the anterior chest wall and incision through the costochondral junctions of the ribs, the sternum was elevated. In elevating the sternum preparatory to its removal for the examination of the thoracic viscera, it was found to be separated at the synchondrosis sternalis between the manubrium and the body of the sternum in such a manner that it could be easily hinged outward, because there was no osseous union as is usually found in a man of this age. The periosteal fibers supporting this synchondrosis were relaxed so that the body of the sternum could be easily displaced backward into the mediastinum to the extent that it would override the lower margin of the manubrium sterni. No fractures of the ribs or clavicles were demonstrated.

The cardiac area was normal in size and the pericardial sac contained the usual amount of clear fluid. The visceral and parietal pericardium was smooth and

glistening. When the heart was removed and opened, the myocardium of the left ventricle was of the usual thickness and of good consistency. The mitral valve was normal. The various cusps of the aortic valve were partially covered with precipitated blood and were ragged (Fig. 1). A careful examination of the various cusps of this valve revealed a transverse slit just below the margin of the left posterior cusp. The right posterior cusp was irregularly torn, fragmented and infiltrated with blood, and the anterior cusp was also extensively torn. There was no gross evidence of inflammatory reaction, the process present was that of an unhealed rupture and fragmentation of the valve cusps. The valve was entirely incompetent. At the base of the anterior cusp the adjacent myocardium and subpericardial adipose tissue was discolored a dark reddish brown which discoloration was apparently due to an old hemorrhagic infiltration. The coronary orifices were patent, and a dissection of the coronary arteries showed no pathological changes. The aorta was smooth and normal throughout the entire length. The myocardium of the right ventricle and also the pulmonary and tricuspid valves were normal.

Both lungs were free from adhesions, and there was a small amount of pleural fluid. Removal and cut section revealed the left lung to contain a moderate amount of edematous fluid and diffuse congestion. This process was most marked in the lower lobe. The right lung was similar throughout but the process of congestion was less marked than in the left lung. There was no evidence of pneumonic consolidation, embolism or infarction. The mediastinum was normal, and there was no enlargement of the lymph glands.

The various viscera of the abdominal cavity were normal except the right kidney which showed a large area of infarction.

Microscopic Sections.—The microscopic sections that were taken through the ruptured cusps of the aortic valve showed a quite thin central fibrous structure and on both surfaces of the valve a precipitate of hemorrhagic material. Immediately adjacent to the fibrous tissue of the valve was a thin layer of plasma cells and a small amount of fibrin, while external to this red blood cells were arranged in a granular material simulating the precipitation type of blood clot. There was no evidence of inflammation or of repair, and the only reaction was the layer of plasma cells.

The sections taken through the myocardium and subpericardial tissue at the base of the aortic valve showed infiltration with round cells and mononuclear cells, and throughout the entire section there was an extensive deposition of blood pigment.

The sections taken through the other portions of the myocardium were normal.

The sections taken through both lungs revealed the alveolar spaces filled with edematous fluid, in which there were a few blood cells. There was a moderate desquamation of the alveolar epithelium in the sections from the lower lobe of the left lung. Many of the alveoli contained heart failure cells.

The sections of the spleen and liver were normal.

The sections of the right kidney that were taken through the area of infarction showed a complete destruction of the kidney tissue in this area and replacement with a hyalinized homogenous material.

Diagnosis: Rupture of the aortic valve, hemorrhagic infiltration about the base of the aortic valve, separation and dislocation of the sternal synchondrosis, bilateral congestion and edema of the lungs, multiple scars over the extremities, and deformity of the left arm and left leg.

DISCUSSION

Traumatic rupture of the aortic valve cusps has occurred most frequently after muscular effort or strain, but a few cases of which fourteen have been proved by autopsy, have occurred following injury

such as falling from a height or a blow to the chest. Barié and Potain[9] produced rupture of the aortic valve by striking with a hammer a board fixed over the precordium of a cadaver. Dufour[17] and Kuelbs[18] were both able to produce rupture of the aortic valve by blows struck to the left chest of the dog. In the case presented, the rupture to the cusps of the aortic valve was caused by the crushing injuries to the thorax incidental to burial under stone and débris. It is unusual that all the cusps of the valve were ruptured and that, while two cusps were fragmented, one contained a transverse perforation. Rupture to the aortic valve occurs most frequently in diseased valves, but in this case a normal valve was injured. The immediate pain in the left chest associated with dyspnea is the most frequent and characteristic symptom of traumatic heart disease. The attacks of syncope and the classical signs of aortic insufficiency aid in the diagnosis of traumatic rupture of the aortic valve during life, especially if the heart has been examined and known to be normal before the accident. These facts should be kept in mind because it is evident that traumatic heart disease is frequently overlooked and that a surprising number of physicians are of the opinion that injury to the normal heart is almost impossible.

SUMMARY

A case of rupture of the cusps of a normal aortic valve is reported. The most frequent and characteristic symptom of traumatic heart disease seems to be pain in the left chest associated with dyspnea. The possibility of diagnosis of traumatic rupture of the aortic valve during life depends greatly upon whether the heart had been examined and found normal before the accident.

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SYMMETRICAL GANGRENE OF THE EXTREMITIES ASSOCIATED WITH PURPURA

Report of a Case in Which Ergotism Was Suspected*

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SINCE Raynaud's classic report, "Local Asphyxia and Symmetrical Gangrene of the Extremities," in 1862, reports of cases of symmetrical gangrene frequently have appeared under the misnomer of "Raynaud's disease." The unusual features found in a case of symmetrical gangrene, which was seen at the clinic in the past year, would seem to merit a report of this case.

REPORT OF CASE

A man, aged forty-four years, a Norwegian farmer who lived in Montana, came to the clinic on June 17, 1935, complaining of loss of eyesight, and gangrene of the hands and legs. For two weeks prior to the onset of the acute phase of his present illness, he had not been feeling well, although he had not had any specific symptoms. On March 30, 1935, he had a mild sore throat. The next day he became acutely ill with chilly sensations, nausea, vomiting, diarrhea with tarry stools, and severe burning pain, which involved the entire body but was most severe in the extremities. The left hand was blue and cold. These symptoms persisted until the next day when he was seen by his family physician.† At that time his temperature was 102.2° F., the pulse rate, 124; and the respiratory rate, 38. Scattered over his entire body, but particularly over the extremities, were many purpuric and ecchymotic spots. A few spots also were observed throughout the mucous membrane of the nose, mouth, pharynx, and the conjunctivae. The gums were spongy and bled very easily. The lips, tongue, and soft palate were badly swollen, and the latter bled from the slightest trauma. Swelling and tenderness of the elbows, knees, and ankles were noted, but there was no redness. Passive movement of these joints produced pain, which was completely relieved by rest. The spleen was tender and large enough to be palpated. The burning pain disappeared within forty-eight hours, but paresthesia persisted for several weeks. Examination of the urine revealed considerable amounts of blood and albumin. The number of erythrocytes and leucocytes was normal, and the platelets numbered 150,000 per cubic millimeter of blood. The stools were tarry in appearance, and examination revealed the presence of blood.

For the next few days after the onset, the patient was severely ill. On the second day of his illness, many of the purpuric spots on the extremities began to appear gangrenous. On the fourth day he suddenly became almost blind and was able to distinguish only the outline of objects. He then became somnolent, irrational, and his condition was considered grave. However, within a period of three or four days he had begun to improve. He became rational again, his temperature subsided; the painful joints improved remarkably, and at the end of two weeks the acute phase of his illness appeared to be over. All of the purpuric spots on the head, trunk, and mucous membranes disappeared without leaving any trace of their presence.

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†We are indebted to Dr. T. M. Morrow of Scobey, Montana, for a detailed account of the onset of the patient's illness.

The sequelae involved the eyes and extremities. The visual impairment, along with photophobia and some redness of the conjunctivae, persisted until the patient came to the clinic on June 17. The gangrenous spots became more marked than they had been, and gradually involved the distal two-thirds of the thumb and the index, middle, and ring fingers on the right hand; the tips of the middle and little fingers on the left hand, a small portion of the dorsal surface of the middle finger on the left hand; almost the entire outer surface of the left leg; a small portion of the outer aspect of the right leg; all of the toes of the right foot, and a part of the distal and lateral portions of the plantar surface of the right foot.

Following the acute phase of his illness, he noted numbness in his hands and feet, and loss of sensation in his legs and feet. About eight weeks after the onset of the condition, all the toes of the right foot sloughed, and a short time thereafter the gangrenous spots on the outer aspect of the left leg sloughed and left a large ulcer. Gradually, all of the gangrenous spots on the lower extremities sloughed, and partial healing occurred. However, the gangrenous spots on the fingers remained.

An interesting side light on the patient's illness was the coincidental illness and death of his mother. The patient and his mother had lived together for many years. Apparently, the mother, who was sixty-four years of age, had been suffering for some time with a mild congestive heart failure. Two days after the onset of her son's illness, she suddenly became acutely ill; she vomited, had diarrhea, and passed tarry stools. When seen within twenty-four hours by her family physician, she was acutely ill and stuporous. She had a marked congestive heart failure, dyspnea, cyanosis, and edema which extended up over the lower part of the abdomen. On her forehead and thorax there were petechial spots, and a few hours before her death similar spots were noted on her abdomen and lower extremities. These spots were similar to those which were noted on the son, but were less extensive. She died suddenly within twenty-four hours of the onset of her illness. Necropsy was not permitted.

When examined at the clinic, the son was well developed but poorly nourished. The value for the systolic blood pressure was 98 mm. of mercury, and that for the diastolic was 60 mm. of mercury. The pulse rate and the temperature were normal.

There was marked impairment of vision. With the right eye he could distinguish moving objects, but in the left eye only light perception remained. A bilateral subacute uveitis was present. Bilateral cataracts were present, and both pupils were completely adherent.

Examination of the upper extremities revealed that the ulnar and radial arteries were pulsating normally. On the right hand the distal two-thirds of the thumb, index, middle, and ring fingers, and the tip of the little finger were dry, black, and completely gangrenous (Fig. 1). On the left hand, a similar condition involved the distal third of the middle finger, the tip of the little finger, and a small spot on the dorsum of the middle finger in its middle third. The line of demarcation between the healthy and gangrenous portions was clean-cut, and healthy granulations were noted proximally at the line of demarcation. The hands and the fingers were warm up to the line of demarcation and did not reveal any evidence of arterial insufficiency.

Examination of the lower extremities revealed that the popliteal, dorsalis pedis and posterior tibial arteries were pulsating normally. Each of the toes of the right foot had sloughed either at the distal or proximal interphalangeal joints, and the stumps were almost healed (Fig. 2). There were ulcers on the plantar surface of the right foot and on the lateral aspect of the lower third of the right leg with evidence of recent healing of several small ulcers in this situation. On the left leg there was a very large ulcer which involved almost the entire lateral aspect of this leg. There was evidence of recent healing in its upper margins. The toes of the

left foot were not involved. There was fairly healthy appearing granulation tissue at the bases of the ulcers, and there was evidence of recent healing around their margins. The ulcers were very insensitive to pain, as were the entire legs and feet. The feet presented no clinical evidence of arterial insufficiency.

Neurological examination revealed mild to moderate loss of touch and pain sensation in the legs and feet. The sensory changes in the legs and feet were noted to be most marked peripheral to the ulcers. The neurological diagnosis was mononeuritis multiplex, which probably was the result of infarctions.

Laboratory examination revealed the concentration of hemoglobin to be 12.6 gm. in each 100 c.c. of blood; the erythrocytes numbered 4,170,000; the leukocytes, 5,800; and the platelets, 158,000, respectively, per cubic millimeter of blood. Urinalysis on two occasions did not reveal any abnormality. The blood flocculation test was negative. Examination of the urine did not disclose lead or arsenic. A roentgenogram of the thorax was normal. Nasal smears did not reveal *Mycobacterium leprae.* Examination of the spinal fluid revealed normal findings. Agglu-

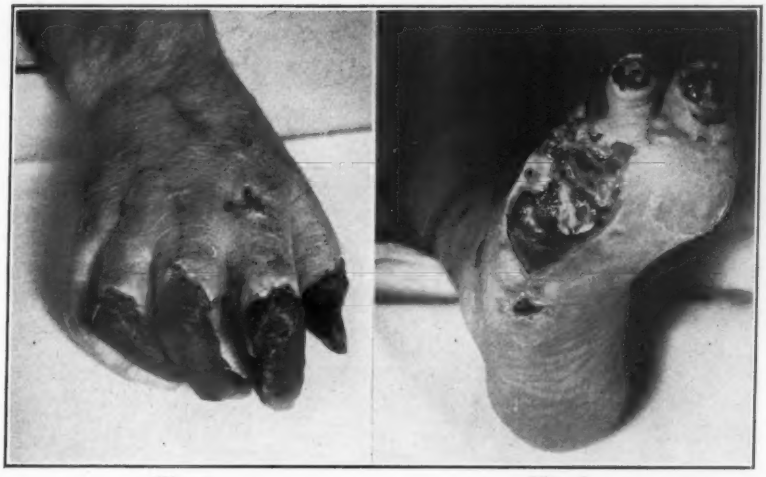

Fig. 1. Fig. 2.

Fig. 1.—Gangrene of fingers.
Fig. 2.—Healing of stumps and large ulcerated region in gangrene of foot.

tination tests for typhoid and paratyphoid fever and with *Proteus X 19* were negative. Nygaard coagulation studies gave a normal coagulation index and platelet volume.

On June 24, 1935, pinch grafts were applied to the ulcerated region on the left leg. The first, second, third, and fourth fingers of the right hand and the first and fifth fingers of the left hand were amputated at the line of demarcation. The grafts took satisfactorily, and the wounds were healing rapidly when the patient was dismissed on September 7, 1935.

The patient returned to the clinic on October 20, 1935. Examination at this time disclosed that the fingers and the ulcers on the left and right legs had healed. Two small ulcers on the plantar surface of the right foot were still open. Examination of the eyes revealed that the uveitis had subsided considerably; otherwise, the eyes were essentially the same as they were when the patient was seen previously. Urinalysis did not reveal any abnormality. There were 339,000 platelets per cubic millimeter of blood. On October 30, a combined extraction of an immature cataract was performed on the right eye. The patient was dismissed December 21, 1935. His chief concern now is his vision.

COMMENT

The diagnostic problem presented by this patient is an interesting though very difficult one. No similar condition had been observed in more than 3,500 cases of peripheral vascular disease seen at the clinic in the previous ten years. The differential diagnosis would seem to demand consideration of a toxic, infectious, or allergic condition.

Careful inquiry did not reveal any possible causative agent, with the exception of a home-ground, whole wheat cereal which the patient and his mother had been eating for several months. Ergot poisoning, therefore, was considered as a possible etiological agent. Ergot is an important disease of rye, wheat, barley, and wild grasses in many sections of the United States. Although gangrenous ergotism has been reported among cattle in Iowa,[10] no case in which ergotism of human beings was the result of the ingestion of ergotized grain or grain products has been reported in this country.

There are certain features in this case which fit the description of ergotism, as given by Barger. In the various epidemics two types of the disease have been noted, that is, the gangrenous and the convulsive. The epidemics have been predominately of one type or the other. The combined form in the same case is extremely rare. According to Barger, the symptoms which are common to both types are a feeling of intense heat and cold, burning pains (St. Anthony's fire) in the extremities, vomiting, severe diarrhea, formation of red and violet spots and vesicles in the skin, and impairment of mental function. In the gangrenous form, the skin becomes cold and livid and the diseased part may become black and gangrenous very suddenly. In the convulsive form, severe mental reactions, paresthesias, muscular spasms, and convulsions occur, and in some cases there is a residual anesthesia of the skin and even permanent contractures of the muscles and paralysis of the extremities. Visual disturbances are common in convulsive ergotism, and cataracts have been reported in many of these cases.[3] The disease may come on acutely and progress rapidly in either type. There is no mention of the state of the temperature or of the occurrence of gastrointestinal hemorrhages in any of the previous accounts of the disease.

The facts that both the patient and his mother had been eating whole wheat cereal for a considerable time and that both were similarly afflicted at about the same time are suggestive of poisoning with ergot. The occurrence of the burning pain over the entire body and its disappearance the following day, with subsequent development of partial anesthesia of the limbs, are significant. The paresthesias and severe mental reaction and subsequent development of cataracts would indicate that this was a mixed form of the disease. Purpura and thrombocytopenia have been reported to occur following the ingestion of ergot.[8] The violet and red vesicles and spots in the skin, which were observed in previous epidemics, may have been of a purpuric nature.

An analysis of a sample of the whole wheat cereal obtained from the same mill, though of a different batch from that eaten by the patient and his mother, revealed no trace of ergot, as analyzed by Schaer's method. This negative finding is of doubtful significance since an examination was not made of the cereal which the patient was eating at the onset of his illness.

The occurrence of symmetrical gangrene in acute infectious processes has recently been pointed out by Lewis.[5] Typhus fever, typhoid fever, pneumonia, influenza, diphtheria, scarlet fever, and measles are examples of infectious diseases which have been complicated by symmetrical gangrene. The acute phase of this patient's illness might well have been the result of an infectious process of some kind. However, three months after the onset, agglutination tests for typhoid fever, paratyphoid fever, and typhus fever were negative.

Finally, the occurrence of purpura without a marked thrombocytopenia brings up for consideration the anaphylactoid type of purpura. The occurrence of gangrene as a complication of purpura is extremely rare. Both the purpura and the gangrene have almost always been secondary to some infectious disease, usually scarlet fever.[4] Meyer[6] recently reported a case of gangrene following purpura, in which there was a marked reduction in the number of blood platelets. Osler presented a series of cases of purpura in which the visceral manifestations were outstanding. In some of these cases there was necrosis of the skin. All of the patients had allergic manifestations such as angioneurotic edema, and many had had previous purpuric and allergic episodes. Our patient presented evidence of involvement of the eyes, gastrointestinal tract, spleen, and kidneys, which was not markedly dissimilar to that in the cases reported by Osler, and it is possible that the digital gangrene might represent another form of visceral involvement in the form of contraction of smooth muscle not unlike the contraction of the smooth muscle of the intestine, which characterizes Henoch's purpura. However, none of the subjects who had purpura and gangrene had severe burning pains which disappeared suddenly, paresthesias, marked impairment of mental function, or cataracts, such as are seen in ergotism.

SUMMARY

We have presented a case in which a farmer, aged forty-four years, had an acute illness of two weeks' duration, complicated by purpura and an extensive dry gangrene of the digits and of the skin of the legs. We feel that the etiological agent was toxic or infectious in origin, although it appears impossible at this late date to arrive at a definite diagnosis.

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Society Transactions

NEW YORK HEART ASSOCIATION

Heart Committee of the New York Tuberculosis and Health Association

The annual scientific meeting of the New York Committee on Cardiac Clinics was held at the New York Academy of Medicine in New York City on April 28, 1936. The following are abstracts of papers presented or read by title:

The Precordial Lead in Children. Arthur M. Master, M.D., Simon Dack, M.D., and Harry L. Jaffe, M.D. (Mount Sinai Hospital).

ABSTRACT

A preliminary report on chest leads in normal children has been made. Anterior chest leads were studied in seven positions in seventy-one normal children of from two to fifteen years of age. The active electrode was moved across the fourth or fifth interspace from the right of the sternum to beyond the apex of the heart. The following data were obtained: The P-wave was small, usually inverted and often absent. The Q-wave, always present, varied from 2 to 22 mm., increasing as the electrode approached the apex. The R-wave also varied from 2 to 22 mm., but diminished near the apex. Notching and slurring of the QRS were common. The R-T transition was never elevated or depressed over 1 mm. An upright or diphasic T-wave to the left of the sternum, abnormal in adults, occurred in 60 per cent of the children. It was most frequent over the sternum, the incidence decreasing as the apex was approached as well as with increasing age. No correlation was found between the shape of the heart or axis deviation and the presence of upright T-waves. An upright T-wave in the precordial lead in children is not to be considered a sign of cardiac involvement.

Studies of the Circulation in Affections of the Precordium. Harold J. Stewart, M.D., Norman F. Crane, M.D., and John E. Deitrick, M.D. (New York Hospital, Cornell University Medical College).

ABSTRACT

Studies of the circulation have been made in patients exhibiting lesions of the pericardium, three suffering from chronic constrictive pericarditis, and a fourth exhibiting recurrent pericardial effusion. Observations were made of cardiac output by the acetylene method (three samples being taken), of arm-to-tongue circulation time (decholin), of venous pressure (direct method), of blood pressure, of heart rate, of cardiac size (x-ray). Electrocardiograms together with electrical axis shifts were also recorded. All observations were made with patients in a basal metabolic state.

In those with constrictive pericarditis it was found that the cardiac output was less and the circulation time longer than in normal individuals; the venous pressure was elevated. The heart was not large in these patients, and the electrical axis of the electrocardiogram was relatively fixed.

In the patient with recurring effusion after removal of the fluid (1,000 c.c. to 1,500 c.c. was removed every three to four weeks), edema of the face, dyspnea, pleural

effusion, ascites, and swelling of the liver subsided or became less, only to increase or return with reaccumulation of pericardial effusion. In this patient in each instance recurrence of the pericardial effusion was associated with rise in venous pressure, decrease in cardiac output, lengthening of the circulation time, and increase in heart rate. At operation, the pericardial sac was thin and nowhere adherent, and no reason for the recurrence of the effusion was ascertained. Recovery after operation was uneventful, recurrence of the effusion continuing to take place.

Summary.—Affections of the pericardium which obstruct the filling of the heart were associated with increase in venous pressure, increase in arm-to-tongue circulation time, and decrease in cardiac output in the patients who have been studied.

Heart Disease and Pregnancy. Arthur E. Lamb, M.D. (Brooklyn Hospital).

ABSTRACT

Since 1926 a study of the relation of heart disease and pregnancy has been carried on in the prenatal division of the cardiac clinic. One hundred ten patients are the basis of this study.

Analyses were made covering the following points: (1) incidence of functional murmurs; (2) incidence of organic lesions; (3) etiology of the organic lesion; (4) anatomical diagnosis, and the relation of the anatomical diagnosis to heart failure and death; (5) the relation of the age of the patient to decompensation; (6) the relation of parity to heart failure; (7) the months of pregnancy in which heart failure occurs.

The number of decompensations and deaths occurring in each functional class is shown. It was found that twelve patients in Classes I and II A became decompensated. Analysis of the cases was made according to the size of the heart, the presence of a long rumbling diastolic murmur at the apex, the duration of the rheumatic disease, the presence of signs of rheumatic activity, and the presence of auricular fibrillation. From this analysis it was concluded that these factors in addition to the functional classification must be considered in the evaluation of a pregnancy risk.

Coronary Artery Disease in Women. Hyman Levy, M.D., and Ernst P. Boas, M.D. (Mount Sinai Hospital).

ABSTRACT

Although, in women, precordial pain is a very common symptom, coronary artery disease is unusual in the absence of diabetes and hypertension and is rare in women under fifty years of age. Ignorance of this fact leads to many mistaken diagnoses. During the past seven years in an office practice representing largely patients referred for cardiovascular diagnosis, we saw 171 cases of coronary artery disease in women, which represents 10.3 per cent of all of the women seen. In the same period we saw 1,059 cases of coronary artery disease in men, representing 49.6 per cent of all male patients. The frequency is 4.8 times as great in men as in women. Of the 171 cases in women, 73.7 per cent occurred in the presence of hypertension alone, 14 per cent in the presence of both diabetes and hypertension, and 3.5 per cent in the presence of diabetes alone. In only 8.8 per cent was there neither hypertension nor diabetes, and only one-third of this small group were women under fifty years of age. A large part of the study is devoted to the evaluation of symptoms and the establishment of criteria for the diagnosis of coronary artery disease in women. This is based largely on a follow-up study undertaken to check the accuracy of the original diagnosis.

The Effect of Potential Variations of the Distant Electrode on the Precordial Electrocardiogram. Charles E. Kossmann, M.D., and Bertha Rader, A.B. (New York University College of Medicine, Bellevue Hospital).

ABSTRACT

Leads IV, V, and VI of Wolferth and his associates were recorded in nine subjects with widely varying electrical axes in the standard leads. The potential variations of the left leg, and of precisely the same points on the precordium and on the back used to record Lead IV, were then obtained by the method of Wilson and his associates. All electrocardiograms were taken simultaneously with standard Lead I. In every patient the potential variations of the precordial electrode qualitatively and quantitatively dominated the form of the curve obtained when this electrode was paired with a distant one placed either on the back or on the left leg. In Leads IV and V the effect of the distant electrode was usually small but exceedingly variable. When the position and size of the exploring electrode were kept constant, marked differences between Leads IV and V were due only to considerable differences between the potential variations of the back and the potential variations of the left leg.

Papers Read by Title

Transient Ventricular Fibrillation: Its Clinical and Graphic Manifestations During Established Auriculoventricular Dissociation. Sidney P. Schwartz, M.D. (Montefiore Hospital).

ABSTRACT

Correlated observations of the clinical and graphic manifestations of syncopal seizures in six patients with A-V dissociation reveal that a clinical diagnosis of the cardiac mechanism responsible for these seizures may be made from a knowledge of the following:

A. The prefibrillatory mechanism. This is characterized by an acceleration of the basic ventricular rate. This acceleration may be effected through (a) a simple and progressive shortening of the interventricular periods; (b) a steplike progression of both auricles and ventricles; (c) the interposition of a single extrasystole changing a slower rhythm to a faster one; (d) recurrent short runs of tachycardia arising in an ectopic focus of the ventricles and alternating with the periods of heart-block; (e) a tachysystole in which a rapid auricular rate keeps pace with a rapid ventricular rate; and finally (f) the ventricular rate may be increased by isolated premature beats of the ventricles which would appear in rapid succession and accelerate the heart before the cardiac mechanism responsible for syncope set in.

B. The postfibrillatory mechanism which follows the revival of the heart. This is characterized by a progressive acceleration of an intermediary idioventricular rhythm, so that, if the heart rate following an attack of syncope is noted to increase in this manner, it is fair to assume that the period of syncope which anteceded this mechanism was the result of ventricular fibrillation.

C. The use of epinephrine hydrochloride. In patients in whom standstill of the ventricles is the cause of syncope, epinephrine hydrochloride merely accelerates the idioventricular rate or does not influence it at all. In patients in whom ventricular fibrillation is the underlying cardiac mechanism, epinephrine hydrochloride yields short runs of ventricular oscillations which are short runs of ventricular fibrillation.

The Electrocardiogram in Acute Nephritis. Arthur M. Master, M.D., Harry L. Jaffe, M.D., and Simon Dack, M.D. (Mount Sinai Hospital).

ABSTRACT

In a study of the cardiovascular system in acute nephritis, definite electrocardiographic changes were observed. Electrocardiograms, including chest leads, were taken at frequent intervals in thirty cases; the average number per patient was five. The abnormalities included:

Tachycardia	5	Slurring QRS	7
Premature beats	3	Large Q_3	2
Auricular flutter	1	Absent Q_4	2
P-wave change	3	R-T deviation	2
Prolonged P-R interval	5	Low T-waves	10
Left axis deviation	10	Inverted T_1 or $T_{1,2}$	8
Low voltage QRS	11	Inverted T_3	9
High voltage QRS	3	Upright T_4	7

The absence of a Q-wave in the chest lead in two cases is especially significant since such a finding has usually been considered evidence of myocardial infarction. In all cases the electrocardiographic changes were progressive from day to day, and in the majority the changes had disappeared at the end of the period of observation. Nine of the patients were fifteen years old or less; in them the changes were less marked. The oldest patient was forty-one years old. Correlation was made between the electrocardiographic changes and the clinical and laboratory evidence of cardiovascular involvement, such as hypertension, cardiac enlargement, peripheral vascular sclerosis, and cardiac insufficiency. It is concluded that in acute nephritis there is involvement of the heart, probably as part of the general vascular disturbance.

Multiple Attacks of Coronary Artery Thrombosis. Arthur M. Master, M.D., Harry L. Jaffe, M.D., Simon Dack, M.D (Mount Sinai Hospital).

ABSTRACT

A study was made of the incidence, course, prognosis, and mortality of multiple attacks of coronary artery thrombosis.

Two hundred twenty-four patients suffered 352 attacks, of which we observed 246. Ninety-three (41 per cent) experienced more than one attack, 221 in all. The mortality for all attacks was 14 per cent and increased with each recurrence (3.7 per cent, first; 20 per cent, second; 40 per cent, third). The incidence of multiple attacks was similar in both sexes and in all age groups.

The majority of multiple attacks occurred within one year. The importance of the reappearance of hypertension was studied.

Cardiac insufficiency both of the left and of the right ventricle was more common in later attacks than in the first. It was investigated clinically, by study of the circulation time, the vital capacity, and the venous pressure.

Post-mortem examination in seventeen cases showed evidence of old, as well as recent, thrombosis in twelve. In these, all the main vessels were usually occluded. The site of a recent thrombosis was not related to a previous one. Of the five patients dying in the first attack, death was occasioned by cerebral or pulmonary complications in four. In two patients, two or more arteries were occluded simultaneously. Thus single artery thrombosis is rarely fatal.

A Correlative Study of the Cardiac Outline. Bernard S. Epstein, M.D. (Montefiore Hospital).

ABSTRACT

The cardiac contour was studied in twenty-eight post-mortem cases. Observations were made with the heart in situ. Precautions were taken to reduce cardiac displacement to the minimum.

The left border of the normal heart consists of the arch of the aorta, the pulmonary artery and in some cases, a small portion of the conus pulmonalis, and the left ventricle. The right ventricle appears on the right border only in cases with marked right ventricular enlargement.

The left auricle rarely appears on the left border. The left auricular appendage may be border forming, but is of little significance. An unusual case in which a dilated left auricle appears on the left border of the heart is described.

The mode of origin of the pulmonary artery from the conus pulmonalis varies considerably. It is horizontal in the transverse type of heart, and vertical in the "drop" type of heart.

Enlargement of the left ventricle may rotate the heart clockwise, thereby deviating an otherwise normal left auricle to the right.

Department of Reviews and Abstracts

Selected Abstracts

PROCEEDINGS OF THE GERMAN ASSOCIATION FOR THE STUDY OF THE CIRCULATION*

EIGHTH ANNUAL MEETING, WIESBADEN, MARCH 24 AND 25, 1935

The main topic for this meeting was the interrelation of circulation and respiration. The following reports were made:

1. The Physiological Coordination of Respiration and Circulation. W. R. Hess (Zurich).

A review of recent work was presented. The author first considered CO_2 and O_2 transport. Since the tissue cells are the source of CO_2, their blood flow must be adjusted to their CO_2 production. This is done by means of the arterioles. The diversion of blood to active tissues leads to a decrease of blood supply to the respiratory center which decrease results in its stimulation, unless the cardiac output is augmented sufficiently to counteract the effect. Arterial reflexes resulting from the blood pressure changes further modify these adjustments. A balance exists between the CO_2 transported to the lung by the blood and the CO_2 eliminated by the lungs. This is regulated by the CO_2 concentration of the blood acting reflexly on the respiratory center by stimulating certain receptors located in blood vessels. It follows, therefore, that every adjustment of the circulation which alters the concentration of CO_2 in the region of these receptors will modify respiration. These receptors are tuned to keep the CO_2 from accumulating in the tissues.

Similar adjustments can be shown to exist with regard to O_2, except that the adjustments here are to prevent O_2 depletion in the tissues. The adjustments for O_2 are not so fine because O_2 diffuses much more slowly than CO_2, and for the same reason there is a greater time lag.

In considering these integrations one must bear in mind the following: (1) that the body has a large capacity to buffer CO_2, (2) that changes in circulation and respiration modify one another in mechanical ways, and (3) that respiratory adjustments are for the body as a whole whereas circulatory adjustments are summations of local actions in various organs.

The author then discussed changes in blood flow and blood pressure during the respiratory cycle, pointing out that within certain limits these do not modify the blood flow per minute. He next elaborated on the local control of blood flow in tissues. He next brought out the view of Heymans' that receptors which start the reflexes to adjust respiration are located in the aortic and carotid sinus regions where end-organs are located which also reflexly regulate the circulation. The evidence pro and con for this view is presented. This masterful presentation is concluded with a discussion of the rôle played by the higher nervous centers located in the hypothalamus. The present accumulation of evidence points to the sub- and hypothalamus rather than the medulla oblongata as the regions which may play the dominant rôle in these adjustments.

*Edited by Eb. Koch and published by Theo. Steinkopff, Dresden and Leipzig, 1935.

2. Alterations in the Respiratory Mechanism and Their Effects on the Circulation. K. F. Wenckebach (Vienna).

The author discussed the comparative physiology of these two systems to show that (1) all the blood must pass through the ventilation chamber before going to the peripheral organs and (2) that the ventilation chamber acts as a suction and force pump for both air and blood. He then reviewed the mechanism of the movements of the thoracic cage. He discussed the various types of respiratory dysfunction and how they are produced (viz., pneumonose, chest deformities and emphysema) and pointed out that these change the normal beneficial action of respiration into a detrimental one. This occurs in part by displacement of the heart and of the diaphragm, by increasing the effort involved in breathing, by decreasing the pumping action of respiration which facilitates the venous return, and by increasing the resistance to pulmonary flow.

3. Pulmonary Circulation in Normal and Pathological States. M. Hochrein (Leipzig).

The output of the right and left ventricle are equal when conditions are stable. The lung vascular-tree is a passive bed that mirrors the disharmonies of the right and left heart. The blood flow is a function of the pressure difference existing between the right ventricle and the left auricle. In fact, pulmonary arterial pressure is the stabilizer of maladjustments in pulmonary flow. There is an optimum rate and depth of respiration as far as blood flow is concerned, deviation from which causes decrease in flow; inspiration augments inflow into the lungs and expiration augments outflow from the lungs.

The lungs normally contain up to one-fourth of the blood in the body. They are one of the blood reservoirs of the body. Increase in intraalveolar pressure decreases the amount of blood in the lung, and a decrease in this pressure has the reverse action. Reflex vasoconstriction of the pulmonary vessels can be demonstrated. Adrenalin normally causes an accumulation of blood in the lungs, but when the lungs are engorged, it has the exact opposite action. Short periods of static effort cause a decrease in the lung blood content, but most exercises of longer duration lead to an increase in lung blood volume which quickly disappears following cessation of the exercise.

While these changes in lung blood content provide for adjustments in gas exchange, they are more important in acting to neutralize any tendency for the output of the right and left heart to become unequal. These changes in lung capacity also operate to permit quick adjustment of the output of the left heart to body needs. Some of these adjustments are of reflex nature. The origin of some of these is in the pulmonary system.

Changes in the pulmonary circulation occur not only in left heart failure, pulmonary sclerosis, emphysema, kyphoscoliosis, but also follow coughing, strain, and asthmatic attacks. The author suggests that sighing respiration may be a compensatory mechanism to accelerate blood flow.

Damage to the lung vessels can cause edema, and insufficiency of the lung vessel muscles may lead to hypostatic pneumonia. The author suggests that a reflex from the abdominal organs may lead to serious lung engorgement with sudden dyspnea as a result.

Clinically, the state of the lesser circuit can be determined by the degree of cyanosis and tachypnea, by the intensity of the second pulmonic sound, by the presence of catarrh, pulmonary edema, and stasis in the greater circuit, by the x-ray appearance of the lungs, and more quantitatively, by the vital capacity. Unfortunately, the value of vital capacity measurements is lessened since it requires the conscious cooperation of the patient.

Luminal in man and barbiturates in animals seem to lessen shock following pulmonary embolism. The author believes that artificial respiration, as with the Drinker machine, is beneficial in convalescing patients, and he recommends in these cases stimulation of the respiratory center.

4. Functional Structure of the Lung Vessels. A. Benninghoff (Kiel).

There is a sphincter at the mouth of the pulmonary artery where it joins the right ventricle. This is the homologue of the bulbus musculature. In man there are no purely muscular type of pulmonary arteries such as constitute the peripheral arteries in the systemic circuit. The pulmonary arteries are either of the easily distensible elastic type or the precapillaries. The former arteries have a system of elastic and muscular fibers so arranged that the muscles act on the elastic strands and vice versa. The alterations in the muscle fibers prevent the vessel wall from acting as a pure elastic body. In this way the vessels are kept from overdistending. The architecture is different in other mammals. He was unable to find ampule formation or arteriovenous shunts in the lung capillary bed.

The veins have more circular muscles than the arteries. In some mammals the veins have also been found to contain cardiac muscles which suggests active contractions.

5. The Resistance of the Lung Circulation and the Mechanisms of Its Regulation. R. Wagner (Breslau).

In animals with chest closed an electric transmission manometer shows that the maximum pressure in the right ventricle is higher during inspiration than expiration. Anything causing stretching of the lungs causes an effect similar to inspiration, presumably by increasing the pulmonary resistance. Vasomotor influences also affect pulmonary resistance. These changes in resistance are buffered by variations in the number of capillaries open. There is thus a reserve of unopened capillaries which vary from time to time.

6. Acute Cardiac Pulmonary Edema. F. Schellong (Heidelberg).

Acute cardiac pulmonary edema occurs in mitral stenosis, but it is particularly common in hypertension and left heart failure. Hindrance to pulmonary onflow following left heart failure is not the only cause. The author states that nervous factors and the amount of blood entering the lungs play important rôles. These combine to cause overfilling of the lung vessels and thus lead to lung edema.

In mitral stenosis congestion of the lung and hindrance to onflow are constantly present so that edema follows readily whenever there is an increase in the amount of blood entering the lungs. Therefore, failure of the right ventricle and venesection by lessening the amount of blood entering the lungs improve the condition. Nitrites act by increasing the splanchnic bed and thus cut down the flow to the right heart. The author states that patients with mitral stenosis can be regarded as feeling vasomotor reactions in their chests. The author believes that digitalis may bring on an attack of pulmonary edema in patients with mitral stenosis and advocates nitrites as a preventive.

Two types of pulmonary edema are found, one occurring in the presence of chronic pulmonary congestion, the other in its absence. The former type occurs at night or following slight effort when the patient is lying down. Dyspnea is an important and dominant symptom and is associated with cyanosis. The treatment is the treatment for congestive failure.

The second type follows rage. It is accompanied by a sense of pressure in the chest, breathing becomes rapid, the patient has no difficulty holding his breath,

and there is no cyanosis. Morphine brings quick relief, as do sedatives and vasodilators. The blood pressure rises in both forms, and the cardiac output increases. The second form, the author believes, is due to nervous reflexes which ultimately lead to the edema of the lungs. The author conceives the elevated blood pressure and increased heart output as the precipitating factors for the attacks. When dyspnea occurs, this sets up a vicious cycle. Nitrites are effective by leading to dilatation of the splanchnic vessels, a decrease return to the right heart and a lowering of the arterial blood pressure.

7. Pneumonose. R. Schoen (Leipzig).

Pneumonose indicates a disturbance of O_2 absorption by the blood resulting from a decrease in the permeability of the alveolar wall. The O_2 tension in the alveoli is normal, and yet the arterial O_2 content is decreased. The author mentions the difficulties of proving the existence of this condition which is inherent in the methods available of obtaining true samples of all the alveoli and of alveolar blood. Clinically, the anoxemia in compensated mitral stenosis with lung congestion may be of this form. There are also forms of toxic origin, particularly those which in a more advaced stage cause pulmonary edema. Interstitial pneumonitis may act as a barrier to O_2 exchange and so may congestion of the alveolar wall.

8. Respiratory Excursion of the Heart and Large Vessels—A Roentgenkymographic Demonstration. G. A. Weltz (Munich).

Respiratory changes in the position of the heart depend on movements of the diaphragm. These changes may be quite marked and cause a marked alteration in heart shadow and so make estimations of heart size very inexact. Usually the heart shadow is found to be decreased in inspiration.

During inspiration, the heart shadow is usually larger than in expiration, and the pulsations of the heart borders are smaller. Respiratory sinus arrhythmia may alter this. The aorta and pulmonary artery move laterally as the heart shadow increases in size. The pulsations of these vessels also vary during the respiratory cycle. In deep expiration the pulsations of the right and left margin of the "aortic" shadow are out of phase. The liver gets less opaque during inspiration.

9. The Activity of the Lung Capillaries. W. Tiemann (Munich).

Not all of the lung capillaries are functioning, some of these being held in reserve. The caliber of the capillaries is determined by the activity of the arterioles and by the state of the alveolar wall. Blood flow is best in inspiration and worst in expiration. However, deep inspiration narrows the capillaries by elongating them. Oxygen, carbon dioxide, adrenalin and histamine have no direct action on the capillaries. The author finds that hypophysin acts on the arterioles. Unlike the systemic capillaries, those of the lung are not actively contractile. These differences may be due to the fact that the blood vessels of the lung serve the body at large rather than the lungs themselves. The lung parenchyma, however, is nourished by the bronchial blood vessels which are part of the systemic circuit and the capillaries of which behave like systemic capillaries.

10. The Dependence of Stroke Volume on Breathing. R. Herbst (Kiel).

The author has used pulse pressure as an index of stroke volume, and his computations suggest that there is cyclic respiratory variation of 15 c.c. during quiet respiration, the stroke volume increase beginning in early inspiration and reaching a maximum early in expiration.

The results are explained as the delayed effect of increased venous return to the right heart as modified by changes in capacity of the lung circuit. The venous return

to the right heart increases in inspiration and decreases in expiration. In deep respiration the differences in output during the respiratory cycle may be greater than 50 c.c.

11. Relation of Breathing to the O_2 Saturation of Arterial Blood. K. Matthes (Leipzig).

The author gave a description of a method of determining O_2 saturation in unopened vessels. It involves photoelectric registration of monochromatic light. He used it in the clinic by transilluminating portions of the finger. By using a finger plethysmograph, he can get simultaneous changes in blood volume and so rule out changes in hemoglobin concentration in this part. Histamine is used to give widely dilated capillaries. The author found the ear better suited for O_2 saturation measurement, but it was not feasible to use a plethysmograph for this organ. Instead, he used the transmitability of a green light in the other ear as a control.

In animals a respiratory variation of O_2 saturation was found to occur. The time relation between the onset of inspiration and the rise in O_2 saturation gives an idea of how long it takes for O_2 to get from the air passages to the skin capillaries. This is shortened after exercise. This respiratory cycle fluctuation of O_2 saturation does not occur in normal man. Patients with bronchitis and dyspnea, however, do show respiratory cycle variations in O_2 saturation. Changes in O_2 saturation also occur even in normal persons during speech and hyperventilation.

12. Vasomotor Influences and Blood Pressure in the Lesser Circuit. A. Strubell-Harkort (Dresden).

In this polemic and lengthy discussion of the literature the author concludes that there are vasomotor influences.

13. Respiratory Arrhythmia in Canines. J. Nörr (Munich).

The author studied 1,000 dogs with chest lead electrocardiograms and determined in each the greatest variation in cycle length during respiration. In the first days of life the heart rate is regular. After a few months, sinus arrhythmia appears and persists up to the ripe age of fifteen years. Fever associated with illness abolishes this arrhythmia. Disease in dogs had no consistent effect on the arrhythmia. Only eight dogs showed extrasystoles and four showed A-V block.

14. Concerning Respiratory Arrhythmia. A. Schweitzer (Bad Nauheim).

This study is based on animal experiments. Changes in the degree of sinus arrhythmia can be effected by the action of the carotid sinus reflexes without modifying respiration. The increased tone of the sinus nerve brings out the reflex just as it slows the heart. A good vagus tone is essential for the arrhythmia. The author concludes that the cause for arrhythmia is in part a reflex from the lungs and in part "irradiation" from the respiratory center.

15. Orthostatic Circulatory Collapse—Gravity Shock Under Reduced Atmospheric Pressures. D. Mateeff (Sofia) and W. Schwarz (Hamburg).

In reduced atmospheric pressures the capillary bed in the muscles is increased as shown by greater ease with which gravity shock occurs in persons 5,000 meters above sea level than in those at sea level. Mountain sickness disappears when the subject lies down or when the limbs are bandaged when he stands.

16. The Significance of Respiratory Curves in Different Diseases of the Heart and Large Vessels. A. Luisada (Naples).

This is a discussion of pneumotachygrams. The author considers that these curves are the resultant of several factors: (a) transmitted impulses from the heart to the chest, (b) movement of the blood out of the chest via the aorta, (c) movement of the blood into the chest via the venae cavae, (d) liver pulsations, and (e) changes in filling of the lung arterial tree.

17. Significance of Simultaneous Measurements of Venous Pressure and Pulmonary Circulation Time in Cardiac Insufficiency. B. Brusik (Prague).

These two measurements permit the determination of right- and left-sided failure. In the former the venous pressure rises, and pulmonary circulation time is slowed. In pure left-sided failure venous pressure rises very little, and pulmonary circulation time is unaffected. A grave prognostic sign is an elevation of venous pressure without much change in pulmonary circulation time. For venous pressure the author used the direct method, for circulation time he used decholin. This study is based on observations on 101 patients.

18. Lung Circulation and Lung Musculature in Atelectasis and Emphysema. E. Reinhardt (Berlin).

The author claims that narrowing of the capillaries and the venules of the alveolar wall occurs before the onset of inspiration and that their widening occurs before the onset of expiration. Hence, these vessel changes are active. He has not seen empty lung capillaries and can produce changes in lung capillaries by vasomotor stimulation. The lung vessel changes can be produced by stimulating the visceral pleura. He believes that atelectasis is due to a contraction of the lung and bronchial musculature probably following a pleuropulmonary reflex. Emphysema he attributes to a nerve paresis.

19. Clinical and Experimental Observations on Respiration and Cerebral Reactions During Heart Standstill. P. Formijne (Amsterdam).

In three patients each Adams-Stokes attack was followed by twitching or apnea. This is attributed to overventilation during heart standstill and transport of this acapnic blood to the brain when the heart beats again. A similar twitching was noted following syncope in one patient. After experimental heart stoppage, apnea occurred regularly and twitching occasionally. Twitching of the muscle seems to require an intact cerebrum. It is not seen in narcosis or coma. While hyperpnea seemed to be the cause of the subsequent apnea, other reflex mechanisms seemed to operate as well.

20. Silicosis, Respiration and Circulation. G. Brückner (Hamm).

This is a report of nine cases. Evidence of right heart failure in the venous pulse occurred in early cases and only occasionally in advanced cases. This evidence of failure is a marked systolic collapse and an exaggerated diastolic wave of the venous pulse.

21. Relation Between "Modality" of Circulatory and Respiratory Disease. S. Koller (Bad Nauheim).

A statistical analysis is presented showing that when grip is prevalent, the death rate from heart disease is increased, but so is the death rate for those persons without heart disease. In the United States, 30 per cent of those reported dying a respiratory death have circulatory disturbances as a contributing cause.

In Czechoslovakia this is true in only 2 to 3 per cent of the cases. In New York State only 3 to 8 per cent of those dying of circulatory disease have respiratory disease as a contributing cause.

22. CO_2 and Carbogen in Handling Diseases of the Peripheral Arteries. A. V. di Cio (Buenos Aires).

In this report 250 c.c. of gas was injected under the skin, the dose being increased daily up to the maximum that the patient will bear (usually 600-700 c.c.). This is used in acrocyanosis and intermittent claudication, apparently, according to the author, with benefit. Carbogen is a mixture of 95 per cent O_2 and 5 per cent CO_2. A capillary microscope shows an opening up of capillaries and an acceleration of flow. It takes from twelve to sixty hours for these gases to be absorbed.

23. Respiration Therapy in High Blood Pressure. R. Trumpp (Bad Liebenstein, Thür).

This report deals with a description of respiratory exercises with purported beneficial results in hypertension.

24. The Significance of Respiratory Changes in Contour of Electrocardiograms as Evidence of Myocardial Damage. L. Condorelli (Cagliari).

Respiratory fluctuation of electrocardiographic contour is evidence of vagal action on the heart and coronary vessels. The appearance of respiratory abnormalities may on occasion be the only evidence of myocardial infarction.

25. The Significance of Selected Leads of Auricular Electrograms in Showing Conduction Disturbances in the Auricles. S. Laufer (Naples).

Two needle electrodes were used. They were placed in the second and fourth interspaces to the right of the sternum for the right auricle. For the left auricle a urethral catheter arranged with two electrodes was inserted in the esophagus so that the electrodes were at the level of the left auricle. In this way, the author found split and broad P-waves not evidenced in the standard leads.

26. Experimental Studies Concerning the Meaning of Thoracic Electrocardiograms. R. Schwab (Bad Nauheim).

An exploring electrode was placed on various regions of the exposed heart of the rabbit which was kept out of contact with the chest, the indifferent electrode being placed in the mouth. No definite characteristic potential field could be obtained on the heart surface. When the heart was surrounded by saline, a definite field was found with one maximum point. When a gelatin cup containing salt solution was placed on the heart, two maxima were found. The author concludes that the two maxima obtained in the closed chest do not depict right and left ventricular activity but rather the edges of the two chambers.

Eb. Koch (Bad Nauheim), in discussing this paper, points out its importance in understanding the thoracic lead. This result is in accord with that of Koch-Momm who found two maxima in a single chambered frog heart under similar conditions.

27. Ligation of the Coronary Veins—Pathological Anatomical Investigations. S. Laufer (Cagliari).

Following ligation of the coronary veins the author found pericardial fibrosis and in early stages subepicardial hemorrhages, especially in the region of the auricle and interventricular septum. Histologically, he found evidence of stasis in the auricular myocardium within forty-eight hours. This was associated with

subendocardial and subpericardial hemorrhages and with thrombosis of the superficial veins. No such evidence was found in the ventricles. After from fifteen to thirty days there was evidence of cavernous capillary channels in the auricles. The muscles were fragmented and fibroblasts appeared. All this was confined to the auricles. After one year, evidence of auricular fibrosis was discovered. In electrocardiograms negative S-T segments and tall pointed T-waves were found. Perhaps this auricular damage is the cause of auricular fibrillation. Condorelli believes the difference in results between the action on the auricles and ventricles depends on the power of the ventricular contractions to empty the coronary blood via the thebesian channels.

28. Concerning Pulsatory Movements of Arteries. K. Hürthle (Tübingen).

The author concludes that pulsatory movement of the arterial wall is the summation of a passive elastic wave which is transmitted at a velocity dependent on the pressure and extensibility of the vessels, and an active wave propagated by muscular contraction.

29. Strophanthin in Warm-Blooded Animals With Fever. P. Martini and F. Grosse-Brockhoff (Bonn).

Fever enhances the action of strophanthin. The author determined the relative lethal dose of this drug in rabbits anesthetized with pernocton in which fever was produced by staphylococcus sepsis. The author could not confirm the idea that strophanthin is borne well by patients with fever.

30. Relation Between Blood Pressure Level and Sulphocyanide Content of Blood. E. Becher, F. Hartner, and E. Herrmann (Frankfort a. M.).

The authors found no difference in sulphocyanide in "pale" and "red" hypertension patients. In both sulphocyanide concentration is occasionally increased.

31. The Pressure Distribution Between the Circulation in "Vasa Privata" and "Vasa Publica." H. Havlicek.

The "vasa privata" are the small lung vessels and "vasa publica" are the large pulmonary arteries and veins. These terms were used by Ruysch in the seventeenth century. The author gives a theoretical discussion of these two parts of the circulation. He emphasizes the importance of arteriovenous shunts.

32. A New Method of X-ray Examination of Aorta. W. Galli (Mailand).

The method consists of passing a tube with a condom on the end into the esophagus. This tube is filled with air (120 c.c.) and its position adjusted under the fluoroscope. The throat is anesthetized for this purpose. Even so, some patients cannot tolerate the procedure. This method permits one to see clearly the action of both the descending and ascending aorta in young subjects. In oblique views, one can visualize the ventricles and auricles more clearly.

33. Observations on the Intact Venous System. A. Schretzenmayr (Cologne).

The author uses a venous oncometer surrounding the vein which records the volume changes within it. These changes are in part passive and in part active. Various studies show that the latter plays an important rôle.

34. Experiments to Locate Venous Thrombosis. A. Jäger (Bonn).

The author found that the following factors are contributory: (1) injury to the vessel wall and (2) changes in the blood flow and an increase in blood coagula-

bility. He reports some experiments on changes in blood flow. When the flow in one branch is slowed, eddy formation occurs and formed elements adhere to the vessel wall.

35. Systematic Investigation of the Action of Electric Currents on the Circulation. S. Koeppen (Leipzig).

The author finds that in death by electrocution, the victim suffers from venous stasis. Hence, death is circulatory and not respiratory. A current of 0 to 25 mA. caused a rise in the blood pressure in narcotized dogs due to tetanus of skeletal muscles. In experiments with dogs, currents between 20 and 100 mA. caused heart stoppage and drop in blood pressure, currents between 100 mA. and 5 amp. are fatal. Currents over 5 amp. have an action similar to that of 25 to 100 mA. but, in addition, cause overheating with irreversible damage to the central nervous system.

Greene, Charles W.: Control of the Coronary Blood Flow by Reflexes Arising in Widely Distributed Regions of the Body. Am. J. Physiol. **113**: 399, 1935.

The volume of the coronary flow is influenced by active vasomotor reflexes induced by afferent stimulations arising in all parts of the soma and viscera of the body. The above deduction is based on numerous tests applied to the central or afferent ends of the sciatic, the splanchnic, the phrenic, and the vagus nerves.

The coronary reflex reactions are both dilator and constrictor in type. The coronary dilatations are more readily obtained, are greater in volume, and occur in response to stimuli of the milder and more normal ranges of intensity. The coronary reflex is often diphasic in type in that the initial reflex dilatation may be followed by a late coronary constriction.

AUTHOR.

Brundage, John T., Cantarow, A., and Griffith, R. S.: The Viscosity, Proteins and Lipids of the Blood Plasma in Essential Hypertension. Am. J. M. Sc. **192**: 30, 1936.

The total plasma protein concentration in a group of 21 patients with essential hypertension was within practically normal limits, the average being somewhat higher than the average normal. The albumin and globulin fractions were approximately normal, but the fibrinogen concentration was considerably elevated in a large proportion of patients in this series.

The plasma viscosity was generally higher in essential hypertension than in normal individuals but values below the upper limit of normal were present in some instances. There was no demonstrable relationship between the plasma viscosity and the degree of hypertension.

The concentration of fatty acids was slightly above normal and the average considerably above the average normal. The plasma lipids appeared to bear no relation to the plasma viscosity.

The relationship between the various plasma proteins and plasma viscosity may perhaps be more clearly established when the concentrations and relative viscosities of the several globulin fractions can be determined accurately.

AUTHOR.

Abramson, David I., and Weinstein, Joseph: A Basis for the Analysis of Variations in the Form of Electrocardiographic Curves Resulting From Experimental Premature Contractions. Am. J. Physiol. **115**: 569, 1936.

Analysis of electrocardiographic curves obtained by systematic application of stimuli to the epicardial surface of the cat's ventricles revealed the existence of lines of transition for Leads I and III. These lines of transition appeared to divide the

ventricles into two equal, but in each case different, muscle masses, without strict regard to any anatomic boundaries. The line of transition for Lead I ran almost vertically downward over the anterior surface of the heart and then curved around the apex to extend upward over the posterior surface, being situated on the left ventricle, near its right border in most of its course. The line of transition for Lead III extended along the lateral borders of the heart except inferiorly where it curved over the anterior surface of the left ventricle and interventricular septum.

Rotation of the heart on its long axis did not materially affect the location of these lines of transition with respect to the body. Their position on the heart was changed in proportion to the degree and direction of rotation. These results provide further evidence in support of the view that the duration and contour of the initial deflection of ventricular ectopic beats depend upon the location of the impulse initiation with reference to the hypothetical line of transition for a specific lead and so upon the general direction of the impulse spread in relation to the recording line of that lead. These results further support the view that the contour and duration of the initial complex obtained by stimulation of ventricular sites do not depend wholly upon whether the Purkinje system of one ventricle is excited in advance of that of the other. The level at which the stimulus is applied in reference to the long axis of the body plays but a negligible part in determining the type of complex produced.

AUTHOR.

Battro, A., and Quirno, N.: Electrocardiogram in Various Congenital Cardiac Abnormalities. Rev. argent. de cardiol. **2**: 335, 1935.

Electrocardiographic changes personally observed in twenty-one cases of congenital heart diseases are here reviewed. The general statement can be made that congenital cardiopathies have no specific electrocardiographic picture. As an exception, in congenital pulmonic stenosis, the following peculiarities may be found quite often: abnormally high P-wave in one or more leads, marked right ventricular preponderance, frequent inversion of T-wave in Leads II and III. About the same characteristics may be found in cases of combined congenital heart diseases, especially in cases of pulmonic stenosis with interventricular communication. In both these conditions, there can be no right ventricular preponderance or even a left one may be found.

In a case of dextrocardia with pulmonic stenosis the right ventricular preponderance was revealed by inverting the electrodes of the arms.

The electrocardiographic findings in congenital heart disease may be summarized as follows: persistence of ductus arteriosus, interventricular communication and Roger's disease, normal electrocardiogram, although either right or left ventricular preponderance may be found in cases of persistent ductus arteriosus. In congenital aortic stenosis there is left ventricular preponderance.

AUTHOR.

Weber, A.: Cooling and Rheumatism. Ztschr. f. Kreislaufforsch. **28**: 190, 1936.

The author in this theoretical dissertation claims that arteriospasms play the chief rôle in rheumatic affections, but it does not follow that cooling is the only factor precipitating the spasm. Hyperemia works well in rheumatic affection as long as no irreparable anatomical damage is present. The hyperemia can take the form of warm applications, massages, fever therapy, thyroid preparations, or CO_2 baths.

L. N. K.

Schultz, Mark P.: Cardiovascular and Arthritic Lesions in Guinea-Pigs With Chronic Scurvy and Hemolytic Streptococcic Infections. Arch. Path. 21: 472, 1936.

Chronic scurvy and chronic infection with hemolytic streptococci acting synergically may induce nonpurulent carditis in guinea pigs. Valvulitis with fibrinoid degeneration and an intense proliferative reaction constitutes the most prominent lesion. The changes only slightly resemble those seen in cases of rheumatic fever.

For the production of such lesions chronic scurvy at least of mild degree (resulting from a restriction of the vitamin C intake to an equivalent of 6 c.c. of orange juice weekly) is requisite.

Both spontaneous infection with hemolytic streptococci in guinea pigs and that induced in them by inoculation with a strain originally isolated from the lesions of animals with this disease are effective synergically in inducing carditis if their onset does not antedate the development of chronic scurvy, but they are ineffective in this respect if scurvy is induced after a certain degree of antistreptococcic immunity has been established.

Chronic scurvy uncomplicated by infection induces proliferative lesions of minimal extent.

In chronic scurvy of even mild degree there is extensive myositis of the intercostal muscles and of the muscles in the neighborhood of the knee joints. In more severe grades of chronic scurvy slight arthritic changes are demonstrable. These manifestations are apparently unaffected by the presence of infection.

Small localized areas of endocarditis and myocarditis were seen in about half of the control guinea pigs. There were lesions of similar character and distribution in scorbutic and in infected animals, although in the latter they were slightly more extensive and eosinophiles were more frequently present.

Slight aortitis was occasionally noted in all groups of guinea pigs examined. The lesions were apparently not affected by the presence of scurvy, infection, or a combination of the two processes.

AUTHOR.

Leiter, Louis: The Nonspecific Rôle of Pressor Substances in the Plasma of Hypertensive Patients. Arch. Int. Med. 57: 729, 1936.

In preliminary experiments the intravenous injection of heparinized plasma of human blood into unanesthetized dogs produced no significant changes in the mean blood pressure, directly recorded. No difference was observed between the effects of plasma from nonhypertensive persons and the effects of plasma from "malignant" hypertensive patients.

The use of the rat as the test animal, to diminish the dilution of the injected plasma by the animal's blood volume, made possible the demonstration of pressor effects from 51, or 44 per cent, of 117 heparinized plasmas.

The distribution of pressor effects of the plasmas among the different clinical groups was independent of the type of hypertension or of the presence of hypertension.

Plasmas from 17 patients with "malignant" hypertension gave no higher incidence of pressor effects or greater rises in blood pressure than plasmas from 100 other subjects, of whom 83 had various types of hypertension and 17 had miscellaneous nonhypertensive conditions.

Plasmas from hypertensive patients did not increase the response of the blood pressure of the rat to minimal effective doses of epinephrine.

As a result of this study and the related work of other investigators, it must be concluded that there is no satisfactory evidence for the theory that "malignant" or "pale" hypertension (or, for that matter, any common form of clinical hypertension) is caused by the presence of pressor substances in the patient's blood.

AUTHOR.